Technical Report 854

An Evaluation of Four Alternative Orientation Indicators to Accompany the Tank Commander's Independent Thermal Viewer

Sebastiano A. Fisicaro
U.S. Army Research Institute

July 1989

United States Army Research Institute
for the Behavioral and Social Sciences

U.S. ARMY RESEARCH INSTITUTE
FOR THE BEHAVIORAL AND SOCIAL SCIENCES

A Field Operating Agency Under the Jurisdiction of the Deputy Chief of Staff for Personnel

EDGAR M. JOHNSON
Technical Director

JON W. BLADES
COL, IN
Commanding

Technical review by

Billy L. Burnside
Margaret S. Salter

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS --
2a. SECURITY CLASSIFICATION AUTHORITY --	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution is unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE --	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) ARI Technical Report 854	5. MONITORING ORGANIZATION REPORT NUMBER(S) --
6a. NAME OF PERFORMING ORGANIZATION U.S. Army Research Institute Field Unit-Fort Knox 6b. OFFICE SYMBOL (If applicable) PERI-IK	7a. NAME OF MONITORING ORGANIZATION U.S. Army Research Institute for the Behavioral and Social Sciences
6c. ADDRESS (City, State, and ZIP Code) Fort Knox, KY 40121-5620	7b. ADDRESS (City, State, and ZIP Code) 5001 Eisenhower Avenue Alexandria, VA 22333-5600
8a. NAME OF FUNDING/SPONSORING ORGANIZATION -- 8b. OFFICE SYMBOL (If applicable) --	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER --
8c. ADDRESS (City, State, and ZIP Code) --	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO.: 63007A; PROJECT NO.: 795; TASK NO.: 3101; WORK UNIT ACCESSION NO.: H5

11. TITLE (Include Security Classification)
An Evaluation of Four Alternative Orientation Indicators to Accompany the Tank Commander's Independent Thermal Viewer

12. PERSONAL AUTHOR(S)
Fisicaro, Sebastiano A.

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final	FROM 88/09 TO 89/03	1989, July	

16. SUPPLEMENTARY NOTATION
This work was done while the author held a National Research Council/Army Research Institute Research Associateship.

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Armor; Orientation indicator; Abrams tank; Icon; Commander's independent thermal viewer

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This research evaluated four orientation indicators (icons) under consideration for the Commander's Independent Thermal Viewer (CITV). Each icon consisted of three parts: Hull, CITV, and Main Gun. They differed with respect to moving versus stationary parts: (a) Hull stationary with moving CITV and Main Gun, (b) Main Gun stationary with moving Hull and CITV, (c) CITV stationary with moving Hull and Main Gun, and (d) all moving parts. Forty-four M1-qualified tank crewmen were tested as tank commanders with a Unit Conduct of Fire (UCOFT) equipped with a prototype CITV. Results of analyses on performance measures and confidence ratings favored the all moving and Hull stationary icons over the CITV and Main Gun stationary icons and, with one exception, the all moving icon over the Hull stationary icon. In addition, results of analyses on a preference measure indicated that the soldiers preferred the all moving and Hull stationary icons over the CITV and Main Gun stationary icons, but had no clear preference for either the all moving icon or the
(Continued)

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT	21. ABSTRACT SECURITY CLASSIFICATION
☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL Barbara A. Black	22b. TELEPHONE (Include Area Code) (502) 624-6928 22c. OFFICE SYMBOL PERI-IK

ARI Technical Report 854

19. ABSTRACT (Continued)

Hull stationary icon. Finally, over 40% of the soldiers recommended including a cardinal direction indicator with the icon.

Technical Report 854

An Evaluation of Four Alternative Orientation Indicators to Accompany the Tank Commander's Independent Thermal Viewer

Sebastiano A. Fisicaro
U.S. Army Research Institute

Field Unit at Fort Knox, Kentucky
Donald F. Haggard, Chief

Training Research Laboratory
Jack H. Hiller, Director

U.S. Army Research Institute for the Behavioral and Social Sciences
5001 Eisenhower Avenue, Alexandria, Virginia 22333-5600

Office, Deputy Chief of Staff for Personnel
Department of the Army

July 1989

Army Project Number
2Q263007A795

Training and Simulation

FOREWORD

The Fort Knox Field Unit of the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) conducts research on soldier performance and training. Recent work on S & T Task 3101, "Training Requirements for the Future Integrated Battlefield," has involved enhancements to the Abrams tank.

One major enhancement to the Abrams tank is the addition of a Commander's Independent Thermal Viewer (CITV) for use by the tank commander. The Army is considering four alternative orientation indicators (icons), designed to depict the relative orientations of the Hull, Main Gun, and CITV line of sight (LOS), for inclusion with the CITV. This research project attempts to determine which of the icons is superior to the others in providing the tank commander with information about the orientations of the Hull, Main Gun, and CITV LOS.

The results of this research have been provided to the U.S. Army Armor School (USAARMS) Directorate of Combat Developments (DCD) and Directorate of Training and Doctrine (DOTD), the Project Manager-Training Devices (PM-TRADE), and the Project Manager-Abrams Tank Systems (PM-ABMS).

EDGAR M. JOHNSON
Technical Director

AN EVALUATION OF FOUR ALTERNATIVE ORIENTATION INDICATORS TO ACCOMPANY THE TANK COMMANDER'S INDEPENDENT THERMAL VIEWER

EXECUTIVE SUMMARY

Requirement:

The Army is considering four alternative orientation indicators (icons) to accompany the Commander's Independent Thermal Viewer (CITV) in the Abrams tank. Each icon consists of three parts: the Hull, the Main Gun, and the CITV line of sight (LOS). They differ with respect to moving versus stationary parts: (a) Hull stationary with moving Main Gun and CITV LOS, (b) Main Gun stationary with moving Hull and CITV LOS, (c) CITV LOS stationary with moving Hull and Main Gun, and (d) all moving parts. This research was designed to provide the Army with information on the usefulness of the four CITV orientation icons through an examination of soldier performance measures, confidence ratings, evaluations, and recommendations.

Procedure:

Forty-four 19K M1-qualified tank crewmen were randomly assigned to four icon groups. Each soldier was tested under four conditions formed by combining moving or stationary own tank with short- or long-range targets. Testing was done with a Unit Conduct of Fire Trainer (UCOFT) equipped with a prototype CITV using exercises developed for testing and training soldiers on the CITV. Soldiers assumed the role of tank commander and (a) made judgments regarding Hull, CITV, and Main Gun orientations, (b) rated their confidence in those judgments, (c) attempted to detect when a gunner scanned outside of an assigned sector, and (d) evaluated the icons.

Findings:

Results of analyses on performance measures and confidence ratings favored the all moving and Hull stationary icons over the CITV LOS and Main Gun stationary icons. In addition, judgments were more accurate and confidence ratings higher with the all moving icon than with the Hull stationary icon for judgments of Hull, CITV, and Main Gun orientations. However, detection of out-of-sector scanning was better and faster with the Hull stationary icon than with the all moving icon. In general, soldiers preferred the all moving and Hull stationary icons over the CITV LOS and Main Gun stationary icons, but had no clear preference

for either of the preferred icons. Finally, 40.9% of the soldiers recommended including a cardinal direction indicator with the icon.

Utilization of Findings:

The results of this research have been provided to the U.S. Army Armor School (USAARMS) Directorate of Combat Developments (DCD) and Directorate of Training and Doctrine (DOTD), the Project Manager-Training Device (PM-TRADE), and the Project Manager-Abrams Tank Systems (PM-ABMS) for use in decisions pertinent to CITV acquisition.

AN EVALUATION OF FOUR ALTERNATIVE ORIENTATION INDICATORS TO ACCOMPANY THE TANK COMMANDER'S INDEPENDENT THERMAL VIEWER

CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

AN EVALUATION OF FOUR ALTERNATIVE ORIENTATION INDICATORS TO ACCOMPANY THE TANK COMMANDER'S INDEPENDENT THERMAL VIEWER

Introduction

Background

A major problem in system design is the discrepancy between intended and achieved system capability. The U.S. Army has taken the initiative to minimize such discrepancies through the Manpower and Personnel Integration (MANPRINT) program. MANPRINT was designed to enhance human performance in the operation, maintenance, and use of equipment and weapon systems. One aim of MANPRINT is to include the soldier in the design loop early in the development of a system. Often, this inclusion is best accomplished through the use of system models and simulation (Black & Quinkert, 1987).

One application of the MANPRINT program is to the Abrams tank. Several technological advances are being considered as potential improvements to the original design of the Abrams tank. One major enhancement is the addition of a Commander's Independent Thermal Viewer (CITV) for use by the tank commander. The CITV is a stabilized system that displays thermal images on a two-dimensional screen. Thus, one expected advantage of the CITV is enhanced viewing under conditions of darkness and degraded battlefield visibility. In addition, the CITV was designed to provide the tank commander with the opportunity for surveillance and target acquisition independent of the gunner, automatic slewing of the main gun and the gunner's primary sight (GPS) reticle to a target area, and automatic visual scanning of a sector, for which the limits (boundaries) and scanning rate can be selected by the tank commander (for additional information consult General Electric Company, 1988; Quinkert, 1987, 1988, in preparation).

One potential problem with the inclusion of the CITV is known as the "orientation problem." In addition to other tasks, the tank commander is responsible for directing the driver, acquiring targets, and laying the Main Gun on targets. In order to conduct and coordinate these and other activities effectively and efficiently, the tank commander must maintain a constant awareness of the orientations of the Hull, CITV, and Main Gun. In all probability, when buttoned-up in the tank and viewing images on the CITV screen, the tank commander will be unable to determine, on a consistent basis, (a) the absolute orientations of the Hull, CITV, and Main Gun or (b) the relative orientations of the Hull, CITV, and Main Gun (i.e., the orientations of the Hull, CITV, and Main Gun in relation to one another). This orientation problem is likely because the tank commander (a) cannot see the front of the tank and will not always be able to see the driver, who is located in a different compartment, outside the turret and toward the front of the tank, and who directly controls the direction the tank travels (i.e., the

orientation of the Hull), (b) often has little or no information regarding the orientation of the Main Gun, which is slaved to the turret and under the direct control of the gunner, and (c) typically will not be able to determine the orientation of the CITV because the CITV rotates independently of the turret and tank.

There are situations where the tank commander will have absolute or relative orientation information about the Hull, CITV, and Main Gun, but these situations require, for the most part, that the tank commander (a) use visual cues acquired on the CITV screen when scanning with the CITV (e.g., the tank commander sees the sun when looking at the CITV screen, knows that it is late afternoon, and concludes that the CITV is oriented West), (b) look away from the CITV screen to acquire visual cues (e.g., the tank commander sees the driver to his left and therefore knows that the Main Gun is to the right of the Hull), or (c) use nonvisual (e.g., auditory, vestibular, or tactile) cues (e.g., the tank commander senses that the tank is moving to the left and therefore knows that the Main Gun is to the right of the Hull). However, the tank commander cannot rely on these sources of information because they will not always be there at the precise instant the tank commander needs them. Without reliable information regarding at least the relative orientations of the Hull, CITV, and Main Gun, the tank commander is likely to suffer severe disorientation on the battlefield or not use the system.

For example, Dedmon and Mielec (1984) reported the results of a study conducted, in part, to determine the capability of a Surrogate Research Vehicle (SRV) when placed in various command and control (C^2) situations. The SRV consisted of a modified M1 chassis fitted with a low-profile containerized modular external gun turret that incorporated surveillance, communication, and weapon simulator subsystems. Surveillance and target acquisition were conducted by utilizing (a) Staget sights (cameras) connected to two-dimensional black-and-white television monitors and (b) standard M27 vision blocks. One of the Staget sights was slaved to the turret and served to simulate the Main Gun orientation. The Staget sight used by the tank commander was termed the Commander's Independent Electro-optical Sight (CIEOS). The CIEOS was stabilized, could be elevated and traversed, and provided the tank commander with a 360 degree panoramic field of view. Thus, in many respects, the CIEOS is functionally equivalent to the CITV; in fact, the CIEOS can be considered a predecessor of the CITV. In addition, a monopter system was designed to provide crew members with a way of determining the orientation of their camera's line of sight (LOS) in relation to the tank hull. The monopter system consisted of a series of light-emitting diodes (LEDs) attached to the vision blocks at each crew station; as the camera sight was rotated (i.e., as the Staget LOS changed), a different LED was illuminated.

According to Dedmon and Mielec (1984), even though the SRV was equipped with the monopter system, the single most important problem identified during tactical operations and target

engagements was disorientation. Crew members were unable to match direction or coordinate orientation information between television monitors and vision blocks. Thus, targets acquired using one viewing system could not be located with the other system. In addition, when crew members attempted to ascertain the orientation of the Staget LOS, they were forced to look away from the television monitor to glance at the monopter LEDs. Furthermore, crew members could not determine their position on a map to report their location or to make calls for indirect fire support. Of particular concern were the problems encountered by the tank commander. Dedmon and Mielec (1984) noted that the tank commander is subjected to a complex combination of movements: the tank commander's sight rotates under the control of the tank commander, the turret (to which the tank commander's seat and the main gun are slaved) rotates under the control of the gunner, the hull travels in a direction under the control of the driver, and the tank moves vertically as it traverses the terrain. The effect on the tank commander was severe disorientation and, in several instances, nausea.

Dedmon and Mielec (1984) recommended that an orientation indicator that depicts the angular relations between the respective lines of sight and the chassis be located directly on the television screen. Doing so could facilitate attempts to determine relative orientations of the Hull, Main Gun, and Staget LOS, thereby reducing disorientation. However, without information about cardinal direction of at least the Hull, it seems unlikely that disorientation would be eliminated, that problems of coordinating target locations between television monitors and vision blocks would be solved, or that the inability to accurately report tank location or make calls for indirect fire support would be rectified.

In all likelihood, several of these problems will be solved by other proposed enhancements to the Abrams tank: the Intervehicular Information System (IVIS) and the Position Navigation (POSNAV) system. According to Du Bois and Smith (1989), POSNAV is expected to be a major component of IVIS, which is a computer-based Management Information System (MIS) designed to improve command, control, and communication (C^3) performance. POSNAV is an automated navigational system that provides tank commanders with accurate updates of position information, such as tank location. An important feature of POSNAV is an icon that consists of a visual representation of the tank, with Hull and Main Gun (turret) components. The icon is embedded in an analog spatial map display with grid coordinates; thus, the POSNAV icon provides the tank commander with a visual reference for Hull and Main Gun orientations.

Du Bois and Smith (1989) tested the effectiveness of POSNAV over conventional navigational aids and found performance to be superior with POSNAV on 32 of 36 measures. However, there was no requirement to test specifically for performance in determining Hull and Main Gun orientations. Furthermore, the simulators were not equipped with CITVs; therefore, there was no requirement that

the POSNAV icon include or represent the CITV LOS. However, even if the POSNAV icon were to include a representation of the CITV LOS, the tank commander would have to look away from the CITV screen to obtain information about the orientations of the Hull, Main Gun, and CITV LOS. Recall that Dedmon and Mielec (1984) considered this to be a disadvantage of the orientation system used in the SRV and recommended that an orientation indicator be located on the sight monitor. This does not mean that the POSNAV icon should not include a representation of the CITV LOS; rather, it simply means that doing so would not be sufficient. Furthermore, if POSNAV is not included in future upgrades to the Abrams tank (e.g., due to funding constraints), the tank commander would be without an orientation indicator unless one is included with the CITV. Thus, there is ample justification for including an orientation indicator with the CITV and locating it on the CITV screen. The issue then becomes one of determining the appropriate configuration to use.

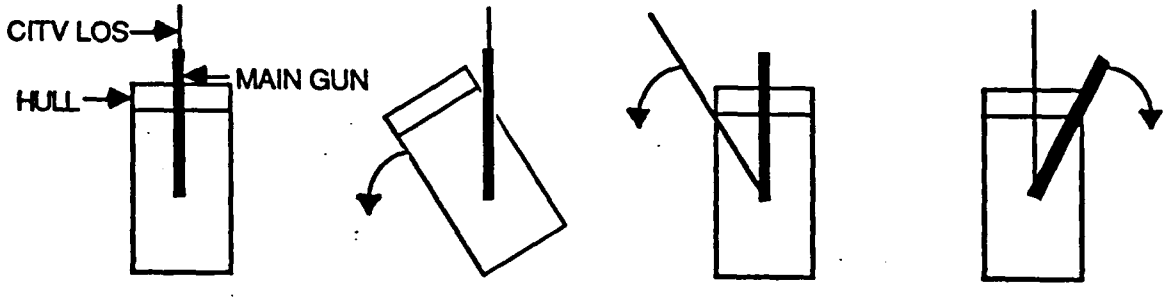
CITV Icon Configurations

In an effort to alleviate some of the orientation problems described above, an orientation indicator (icon), designed to depict the relative positions of the Hull, Main Gun, and CITV LOS, has been developed and is presented on the CITV screen. The CITV icon consists of three parts or components: (a) the Hull, designated by two lines that run across one end of the rectangular figure of the tank, (b) the Main Gun, represented by a short, thick line emanating from the center of the tank, and (c) the CITV LOS, represented by a thin, long line emanating from the center of the tank. Currently, four alternative icon configurations are under consideration. These configurations differ with respect to moving versus stationary components of the icon. The four icon configurations are (a) Hull Stationary with moving Main Gun and CITV LOS, (b) Main Gun Stationary with moving Hull and CITV LOS, (c) CITV LOS Stationary with moving Hull and Main Gun, and (d) All-parts Moving. A description of the factors that cause movement of the icon components is necessary to understand the differences in the four icons.

In the All-parts Moving Icon, (a) the CITV part of the icon moves only when the CITV is rotated and in the direction of that rotation, (b) the Main Gun part of the icon moves only when the Main Gun is rotated and in the direction of that rotation, and (c) the Hull part of the icon moves only when the tank turns and in the direction of the turn. Figure 1 contains a depiction of the movement of the icon components in the All-parts Moving Icon for real-world movement of the Hull, the CITV, and the Main Gun.

In the Hull Stationary Icon, the CITV part of the icon moves in the direction of the CITV rotation, and the Main Gun part moves in the direction of the Main Gun rotation; however, as will be described, these are not the only factors that control the movement of the CITV and Main Gun parts of the icon. The Hull part of the icon remains stationary (i.e., never moves), even when the tank turns; however, the CITV and Main Gun parts of the

icon move in the opposite direction of the tank turn, thus preserving information about the relative positions of the Hull, CITV, and Main Gun. Figure 2 contains a depiction of the movement of the icon components in the Hull Stationary Icon for real-world movement of the Hull, the CITV, and the Main Gun.



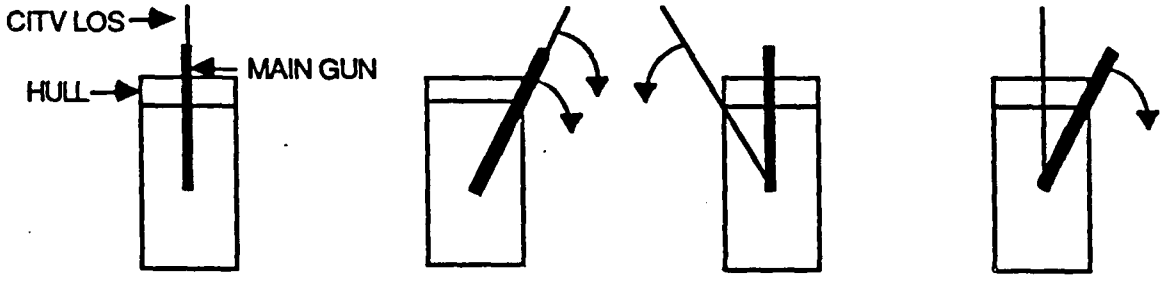
A. HULL, CITV, AND GUN ARE INITIALLY POINTED IN THE SAME DIRECTION

B. ONLY ACTION IS TANK TURNS TO THE LEFT

C. ONLY ACTION IS CITV IS ROTATED TO THE LEFT

D. ONLY ACTION IS GUN IS ROTATED TO THE RIGHT

Figure 1. Depiction of the movement of the three components in the All-parts Moving Icon for real-world movement of the Hull (B), the CITV (C), and the Main Gun (D); straight arrows in A indicate the icon components, and curved arrows in B, C, and D indicate movement of the icon components.



A. HULL, CITV, AND GUN ARE INITIALLY POINTED IN THE SAME DIRECTION

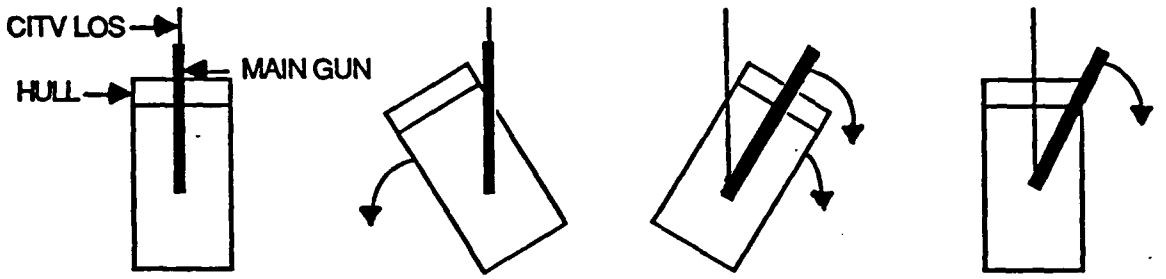
B. ONLY ACTION IS TANK TURNS TO THE LEFT

C. ONLY ACTION IS CITV IS ROTATED TO THE LEFT

D. ONLY ACTION IS GUN IS ROTATED TO THE RIGHT

Figure 2. Depiction of the movement of the three components in the Hull Stationary Icon for real-world movement of the Hull (B), the CITV (C), and the Main Gun (D); straight arrows in A indicate the icon components, and curved arrows in B, C, and D indicate movement of the icon components.

In the CITV Stationary Icon, the Hull part of the icon moves in the direction the tank turns, and the Main Gun part moves in the direction of the Main Gun rotation; however, these are not the only factors that control the movement of the Hull and Main Gun parts of the icon. The CITV part of the icon remains stationary (i.e., never moves), even when the CITV is rotated; however, the Hull and Main Gun parts of the icon move in the opposite direction of the CITV rotation, thus preserving information about the relative positions of the Hull, CITV, and Main Gun. Figure 3 contains a depiction of the movement of the icon components in the CITV Stationary Icon for real-world movement of the Hull, the CITV, and the Main Gun.



A. HULL, CITV, AND GUN ARE INITIALLY POINTED IN THE SAME DIRECTION

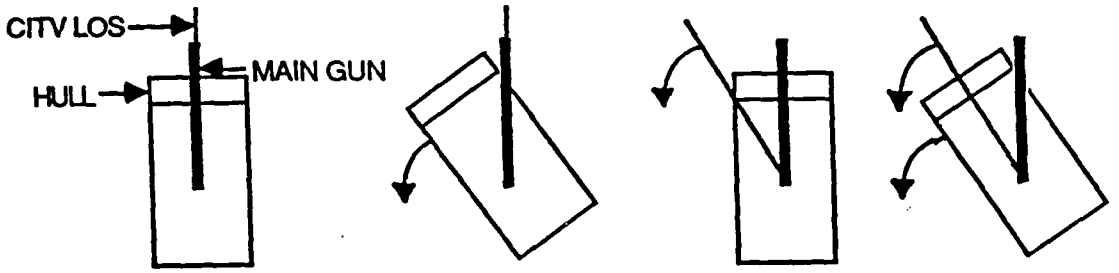
B. ONLY ACTION IS TANK TURNS TO THE LEFT

C. ONLY ACTION IS CITV IS ROTATED TO THE LEFT

D. ONLY ACTION IS GUN IS ROTATED TO THE RIGHT

Figure 3. Depiction of the movement of the three components in the CITV Stationary Icon for real-world movement of the Hull (B), the CITV (C), and the Main Gun (D); straight arrows in A indicate the icon components, and curved arrows in B, C, and D indicate movement of the icon components.

In the Main Gun Stationary Icon, the Hull part of the icon moves in the direction the tank turns, and the CITV part moves in the direction of the CITV rotation; however, these are not the only factors that control the movement of the Hull and CITV parts of the icon. The Main Gun part of the Icon remains stationary (i.e., never moves), even when the Main Gun is rotated; however, the Hull and CITV parts of the icon move in the opposite direction of the Main Gun rotation, thus preserving information about the relative positions of the Hull, CITV, and Main Gun. Figure 4 contains a depiction of the movement of the icon components in the Main Gun Stationary Icon for real-world movement of the Hull, the CITV, and the Main Gun.



A. HULL, CITV, AND GUN ARE INITIALLY POINTED IN THE SAME DIRECTION

B. ONLY ACTION IS TANK TURNS TO THE LEFT

C. ONLY ACTION IS CITV IS ROTATED TO THE LEFT

D. ONLY ACTION IS GUN IS ROTATED TO THE RIGHT

Figure 4. Depiction of the movement of the three components in the Main Gun Stationary Icon for real-world movement of the Hull (B), the CITV (C), and the Main Gun (D); straight arrows indicate the icon components in A, and curved arrows indicate the movement of the icon components in B, C, and D.

Purpose of the Research

This research project is an initial attempt to determine which, if any, of the four icons is superior to the others in providing the tank commander with information about the orientation of the Hull, Main Gun, and CITV LOS. To increase the comprehensiveness of the data and to achieve the goals of MANPRINT, three sources of information were obtained: (a) actual performance measures, (b) confidence ratings from soldiers, and (c) evaluations and recommendations from soldiers.

Overview and Hypotheses

The dependent variables consisted of the following measures: (a) errors in judging the orientations of the Hull, CITV, and Main Gun, which are termed the Position Deviation Scores, (b) the confidence soldiers reported in making those judgments, expressed in the form of Confidence Ratings, (c) the extent to which differences in judgments of Hull and CITV orientations, Hull and Main Gun orientations, and CITV and Main Gun orientations correspond to actual Hull/CITV, Hull/Main Gun, and CITV/Main Gun differences in orientation, which are termed the Position Differential Scores and which measure errors in relative judgments of orientation, (d) detection of a gunner scanning outside of an assigned sector, which is termed the Out-of-Sector Detection Score, (e) time to detect the out-of-sector scanning, which is termed the Out-of-Sector Detection Time, and (f) the

responses to select items from an Orientation Indicator Questionnaire that was designed to allow soldiers to evaluate the icons and to make any recommendations.

Each soldier was tested with one of the icons under four conditions; the four conditions were formed by combining stationary or moving own tank conditions with short- or long-range target conditions. These four conditions were included because it is possible that any differences on the dependent variables caused by the different icons would vary across the conditions. Thus, the independent (i.e., experimentally manipulated) variables are Tank Operational Mode (2 levels: defensive or stationary versus offensive or moving), Target Range (2 levels: short range versus long range), and Icon (4 levels: the four icons).

Given that this research is primarily exploratory in nature, with no theories to guide predictions of results, hypotheses must be somewhat general. With this in mind, the following hypotheses are advanced. Due to the artificial movement of the Hull and the other nonstationary icon component that occurs with the CITV Stationary and Main Gun Stationary Icons, it seems likely that soldiers tested with these icons will make more errors, express less confidence, and report more difficulty in making judgments of absolute orientation of the Hull, CITV, and Main Gun than soldiers tested with the Hull Stationary or All-parts Moving Icons, particularly with a moving tank. Furthermore, due to the artificial movement of the CITV and Main Gun components that occurs with the Hull Stationary Icon and the fact that the Hull part does not move, it seems likely that soldiers tested with the Hull Stationary Icon will make more errors, express less confidence, and report more difficulty in making judgments of absolute orientation of the Hull, CITV, and Main Gun than soldiers tested with the All-parts Moving Icon with a moving tank. If these hypotheses are accurate, it seems reasonable to assume that soldiers would tend to prefer the All-parts Moving and Hull Stationary Icons over the CITV Stationary and Main Gun Stationary Icons, and would tend to prefer the All-parts Moving Icon over the Hull Stationary Icon.

No specific hypotheses are offered regarding position differential errors because (a) these relative position errors do not, of necessity, depend on knowledge of the absolute orientations of the Hull, CITV, or Main Gun, and (b) as indicated earlier, these four icons were all designed primarily to depict relative positions of the Hull, CITV, and Main Gun. In addition, no specific hypotheses are offered regarding detection of a gunner scanning out of sector or the time to make that detection, again because this determination requires an accurate judgment of the relative orientation of the Main Gun to the Hull, not an accurate judgment of the absolute orientation of either component. However, it is possible that even relative position errors (e.g., position differential errors or the detection of a gunner scanning out of sector) could be affected by differences in the four icons.

Method

Research Participants

A total of 44 19K M1-qualified soldiers, E-5 through E-7, stationed at Fort Knox and with recent Conduct of Fire Trainer (COFT) experience, participated in the research project. The research project required approximately 3 1/2 hours of time per soldier. Two soldiers were scheduled for testing each day, one at 0800 hours and one at 1300 hours.

Equipment and Apparatus

The primary equipment and apparatus consisted of a prototype CITV mounted in an M1 Unit Conduct of Fire Trainer (UCOFT). The prototype CITV was designed to meet simulation specifications developed by the Army Research Institute Field Unit at Fort Knox (Quinkert, 1988); both the prototype CITV and the UCOFT were manufactured by General Electric Company. The prototype CITV provides the tank commander with computer generated thermal-like images displayed on a two-dimensional screen; the icon is displayed on the bottom center of the screen. In addition, the prototype CITV allows the tank commander to (a) view the CITV images in either "white hot" or "black hot", (b) use either 3-power or 10-power magnification of the CITV image, (c) adjust the contrast and sensitivity of the CITV image and the brightness of the reticle and symbols (e.g., icon), (d) control the movement of the CITV and the Main Gun, (e) use the CITV to scan the terrain either manually by moving the commander's control handle or automatically by setting the boundaries of a sector to be scanned and selecting a scanning rate, and (f) automatically slew the Main Gun and GPS reticle to a target area (for additional information see the CITV Instructions in Appendix B; General Electric Company, 1988; Quinkert, 1988, in preparation).

The UCOFT is a high-fidelity M1 gunnery trainer designed for use with commander/gunner pairs. The major subsystems of the UCOFT are (a) an enclosed crew station that is a realistic simulation of an M1 tank crew compartment for the tank commander and the gunner, (b) an instructor/operator (I/O) station, (c) a special-purpose computer that produces full-color computer-generated scenarios, and (d) a general-purpose computer that records and summarizes crew performance and controls the interaction of the other subsystems. The crew station includes the sights and the majority of the switches and controls used by the tank commander and the gunner in the M1 tank; however, one sight, the tank commander's Forward Unity Periscope, was removed to allow the CITV to be mounted. In addition, gunner and tank commander Combat Vehicle Crewman (CVC) helmets are included to allow communication between the tank commander and gunner and between the I/O and the two crew members. The I/O station includes two separate display screens for real-time monitoring of gunner and tank commander views of the scenarios, headphones and microphones for communication with the tank crew, a terminal that allows the I/O to control the presentation of exercises, and a

printer for obtaining hard copies of crew performance (for more information see General Electric Company, 1987; Witmer, 1988).

Procedure

First, each soldier was asked to read a printed copy of the Privacy Act Statement of 1974. Then, each soldier completed a paper-and-pencil Biographical Questionnaire designed to provide background information, such as Time in Service, Time as a Tank Commander, etc. (see Appendix A for a sample copy). About 10 to 15 minutes was required to read the statement and complete the questionnaire.

Next, each soldier participated in an orientation and training session designed to (a) explain the purpose of the soldier's participation and (b) familiarize the soldier with the operation of the CITV, the information provided by the icon, and the nature of the tasks the soldier would be asked to perform. All soldiers were instructed in the use of the CITV; however, each soldier was exposed to only one of the four icons. The orientation and training instructions were heard by the soldier through the tank commander's CVC helmet. All soldiers received two sets of instructions: CITV instructions followed by the icon-specific instructions (see Appendix B for copies). Soldiers practiced using the CITV and the orientation indicator as instructions were read to them and were allowed time after receiving the two sets of instructions for additional practice with the CITV and orientation indicator. In addition, soldiers were allowed to ask questions throughout the session. The orientation and training session lasted about 45 to 60 minutes.

Following a 10- to 15-minute rest break, each soldier completed the same four practice CITV exercises in the same order of presentation. The same order of presentation was used so that practice would be standardized. The purpose of the practice exercises was to familiarize the soldier with (a) the upcoming test exercises that were used to generate data for the research project and (b) the tasks that soldiers would be required to perform. The practice session lasted about 45 minutes.

After a 10- to 15-minute rest break, each soldier completed the same four test exercises in order to assess performance using the icon. In this case, however, the order of presentation of the exercises was randomized for each soldier. The test session lasted about 45 minutes.

Finally, each soldier completed an Orientation Indicator Questionnaire designed to provide the soldier with the opportunity to communicate opinions or recommendations regarding the icon (see Appendix C for a sample copy). About 10 to 15 minutes was required to complete the questionnaire. After completing the questionnaire, the soldier was informed in more detail about the purpose of the research, and any additional questions posed by the soldier were answered.

Exercises

The exercises were developed specifically to assess tank commander performance using the CITV and are known as the "CITV Exercises" (for additional information see General Electric Company, 1988; Quinkert, in preparation). The CITV exercises are computer simulated multiple target scenarios containing 3 or 4 groups of targets with 3 or 4 targets per group. Groups of targets are separated from one another by time intervals, during which no targets are presented. The tank commander is (a) unaware that these intervals exist or (b) when these intervals occur; thus, because the terrain is still visible, the tank commander continues to scan the terrain for targets.

In the eight exercises that were used (i.e., four practice exercises and four test exercises), all targets were stationary. Two of each of the following four types of exercises were used: (a) tank in a defensive mode (i.e., stationary) and average target distance less than 1500 meters (i.e., short-range targets), (b) tank in an offensive mode (i.e., moving) and short-range targets, (c) tank in a defensive mode and average target distance greater than 1500 meters (i.e., long-range targets), and (d) tank in an offensive mode and long-range targets. One of each of the four types of exercises was selected to form the set of four test exercises, and the remaining four exercises were used as the set of four practice exercises.

Tasks and Measures

As mentioned earlier, one of the major purposes of the CITV is to allow the tank commander to survey the terrain independently of the gunner. For the purposes of this investigation, each tank commander was instructed (a) to scan a sector of the terrain from the center of the hull to 50 degrees left of center and (b) to acquire and hand off all targets in that sector. A surrogate gunner was used, and the tank commander was informed that the gunner would be responsible for scanning the sector from the center of the hull to 50 degrees right of center. However, each tank commander was informed that it was still the tank commander's responsibility to ensure that the gunner was appropriately scanning the assigned sector. Furthermore, each tank commander was informed that it is also the tank commander's responsibility to maintain an awareness of the positions of the Hull, Main Gun, and CITV LOS.

Once during each exercise, the exercise was temporarily "frozen" and the tank commander was asked to make judgments regarding the positions of the Hull, Main Gun, and CITV LOS using 16-option paper-and-pencil Position Indicator Response Forms (see Appendix D for sample copies). In the moving tank exercises, the exercise was frozen immediately after the tank completed the first turn. This point was chosen to minimize the effects of memory on judgments, thereby allowing the judgments to be more perceptually based than memory based. Furthermore, at this point there were no available targets. In the stationary tank

exercises, the exercise was frozen during one of the intervals where no targets were available. The decision was made to use 16 positions because the Hull component of the icons can assume only 16 positions (i.e., it "jumps" from one position to the next). In addition, because the exercises do not incorporate cardinal direction and the icons do not indicate cardinal direction, the decision was made to arbitrarily designate the "straight up" position as North; the remaining 15 positions were defined in reference to this designation (e.g., the "down" position was designated as South). All soldiers were informed of this when they were instructed in the use of the Position Indicator Response Forms. To indicate the degree of confidence in the three orientation judgments, soldiers used 5-point confidence scales depicted on the Position Indicator Response Forms.

Each tank commander's position responses were scored in two ways. First, they were scored in terms of the number of positions the tank commander's answer deviated from the correct answer, separately for the Hull, Main Gun, and CITV LOS; thus, the minimum score is 0 (indicating that the tank commander gave a correct answer), and the maximum score is 8 (indicating that the tank commander's answer was the exact opposite of the correct position). These three scores will be referred to as Position Deviation Scores. Thus, the Position Deviation Scores measure the accuracy of the tank commander's judgments of the absolute orientations of the Hull, the CITV, and the Main Gun, with lower scores indicating greater accuracy. For example, assume the Hull, CITV, and Main Gun are oriented Northwest (NW), West (W), and North by Northeast (N/NE), respectively, when the exercise is frozen. If the tank commander responds Northwest (NW), West by Northwest (W/NW), and Northeast (NE) on the Position Indicator Response Forms (see Appendix D), the Position Deviation Scores would be 0, 1, and 1 for judgments of Hull, CITV, and Main Gun orientations, respectively.

Second, the number of positions separating the tank commander's judgments of the orientations of (a) the Hull and CITV, (b) the Hull and Main Gun, and (c) the CITV and Main Gun was determined and compared to the actual number of positions separating them; again, the minimum score is 0 (indicating that the difference in the positions reported by the tank commander is correct), and the maximum score is 8. These three scores will be referred to as Position Differential Scores. Thus, the Position Differential Scores measure the tank commander's awareness of the orientations of the Hull, CITV, and Main Gun in relation to one another, again with lower scores indicating greater accuracy. For the above example, the Position Differential Scores would be 1, 1, and 0 for Hull-CITV, Hull-Gun, and CITV-Gun relative orientations, respectively.

At one other point in the stationary tank exercises where no targets were available, the surrogate gunner was instructed to scan out of the assigned 50-degree right sector, from 50 degrees right of the hull center to 100 degrees right of the hull center. Each tank commander was scored in terms of (a) whether or not the

tank commander detected the out-of-sector scanning (0 if the tank commander did not detect and 1 if the tank commander detected the inappropriate scanning) and (b) the amount of time that elapsed (in seconds) before the tank commander detected the inappropriate scanning (maximum time of 30 seconds).

Surrogate Gunner Instructions and Training

Three military UCOFT instructor/operators (I/Os) served as surrogate gunners. Each surrogate gunner was provided with individual orientation and training sessions. The orientation session consisted of a thorough briefing on the purpose of the research project, their role in the project, and the use of the CITV and the icon. They were told that they were to scan a sector of the terrain from one limit of the sector to the other limit in 15 seconds, and that the tank commander would be scanning an adjacent sector to the left of their sector. They were instructed not to acquire or engage any targets that appeared in their sector. However, if the tank commander acquired any targets in the sector being scanned by the tank commander, they were told that the tank commander would slew the GPS reticle to targets he acquired in his sector and hand off the targets to the gunner with a precision fire command, such as "gunner, sabot, tank". They were told that their task was to confirm the identification, finalize the lay, engage the targets by firing the main gun, make the damage assessment (e.g., announce "target" for kills), reengage targets until they were killed, return the main gun to the center of the hull after completing target engagements, and begin scanning their assigned sector again. In addition, the surrogate gunners were told that once during each of the stationary tank exercises they were to scan to the right of their assigned sector such that they would reach the out-of-sector limit in 15 seconds and return to the right sector limit in 15 seconds, for a total of 30 seconds during which they would be scanning outside (to the right) of their assigned sector.

The training session consisted of practice (a) scanning assigned sectors in the stationary tank exercises in 15 seconds, with left and right sector limits defined by landmarks in the terrain, (b) scanning out of sector in 15 seconds to the right to an out-of-sector limit defined by landmarks in the terrain, and then scanning back to the right limit of the appropriate sector in 15 seconds, (c) scanning from the center of the hull to the right for 15 seconds and then scanning back to the center of the hull in 15 seconds in the moving tank exercises, and (d) engaging targets in the tank commander's sector (for this last aspect of training either a civilian I/O or the experimenter served as a surrogate tank commander). In addition, prior to each stationary tank exercise in the practice and testing sessions for the soldiers who were research participants, the experimenter described the landmarks that defined the left limit, right limit, and out-of-sector right limit to the surrogate gunner.

Finally, the surrogate gunners were told that the research project was not a training session for tank commanders; thus, they were instructed not to aid tank commanders in responding to the Position Indicator Response Forms. The surrogate gunners typically were not present during the research participant's orientation and training session or while the research participant completed the Biographical Questionnaire or the Orientation Indicator Questionnaire.

Conditions and Design

Soldiers were randomly assigned to the four different icon conditions. Thus, there were four icon groups, with each soldier exposed to only one of the four icons: 11 soldiers received the All-parts Moving Icon, 11 received the Hull Stationary Icon, 11 received the CITV Stationary Icon, and 11 received the Main Gun Stationary Icon. However, all soldiers received all of the four types of test exercises (i.e., stationary tank/short-range targets, stationary tank/long-range targets, moving tank/short-range targets, and moving tank/long-range targets), with the order of presentation randomized for each soldier.

The independent (i.e., experimentally manipulated) variables were Tank Operational Mode (2 levels: defensive or stationary versus offensive or moving), Target Range (2 levels: short range versus long range), and Icon (4 levels: the four icons). Tank Mode and Target Range were within-subjects factors and Icon was a between-subjects factor. The nonmanipulated variables were the responses to select items from the Biographical Questionnaire. The dependent (criterion) variables were the Performance Measures (Position Deviation Scores, Position Differential Scores, Out-of-Sector Detection Scores, and Out-of-Sector Detection Times), the Confidence Ratings, and the responses to select items from the Orientation Indicator Questionnaire.

Planned orthogonal comparisons involving the four Icon Groups were included in analyses of the Performance Measures, Confidence Ratings, and select items from the Orientation Indicator Questionnaire. The specific comparisons were (a) All Moving and Hull Stationary Icon Groups versus CITV Stationary and Main Gun Stationary Icon Groups (AH-CG), (b) All Moving Icon Group versus Hull Stationary Icon Group (A-H), and (c) CITV Stationary Icon Group versus Main Gun Stationary Icon Group (C-G). The first comparison contrasts the two icons where there is artificial movement of the Hull part of the icon (i.e., the CITV Stationary and the Main Gun Stationary Icons) with the two icons where there is no artificial movement of the Hull part of the icon (i.e., the All Moving and the Hull Stationary Icons). The second comparison contrasts the All Moving Icon, where the Hull part of the icon moves when the tank turns, with the Hull Stationary Icon, where the Hull part of the icon does not move when the tank turns. The third comparison contrasts the CITV Stationary Icon, where the artificial movement of the Hull part

movement of the Hull part of the icon is not controlled by the tank commander (i.e., is controlled by the gunner's movement of the Main Gun).

Results

Statistical analyses were performed on (a) responses to select items from the Biographical Questionnaire, (b) the three Position Deviation Measures, (c) the three sets of Confidence Ratings, (d) the three Position Differential Measures, (e) the Out-of-Sector Detection Scores, (f) the Out-of-Sector Detection Times, and (g) responses to items from the Orientation Indicator Questionnaire. Due to the technical nature of the statistical analyses, relatively nontechnical summaries of the results of the statistical analyses are provided at the end of each of the above sections; the only exception is the section on Biographical Items, because the section is relatively short and nontechnical.

Biographical Questionnaire Items

Means (M) and standard deviations (SD) for select items that reflect mental ability (Item 5: General Technical Score) or experience (Items 6, 7, 14, 15, and 16) are reported in Table E-1 as a function of Icon Group. One-way analysis-of-variance results, with Icon as the between-subjects factor, are reported in Table E-2. Table E-1 and Table E-2 are located in Appendix E. None of the analyses yielded significant F ratios. These results support the conclusion that the random assignment of subjects to Icon Groups was successful in equating the groups on these measures and that any differences between Icon Groups that are found to exist on the dependent variables cannot be attributed to initial differences in mental ability or experience as measured by these items.

Position Deviation Measures

The position deviation measures indicate the extent to which the tank commander's judgments of the orientations of the Hull, CITV, and Main Gun deviate from the actual orientations of the Hull, CITV, and Main Gun, respectively. Thus, higher scores, indicate poorer performance. The data were analyzed using three-way mixed-factorial analyses-of-variance and planned orthogonal comparisons. Tank Mode and Target Range are within-subjects factors, and Icon is a between-subjects factor. The planned orthogonal comparisons are (a) All Moving and Hull Stationary Icon Groups versus CITV Stationary and Main Gun Stationary Icon Groups (AH-CG), (b) All Moving versus Hull Stationary Icon Groups (A-H), and (c) CITV Stationary versus Main Gun Stationary Icon Groups (C-G). However, when Icon interacts with either Tank Mode or Target Range, the main effect of Icon cannot be interpreted without qualification; similarly, the planned comparisons involving Icon Groups cannot be interpreted without qualification when the comparison interacts with either Tank Mode or Target Range (a description of interaction comparisons can be found in Keppel, 1982). Thus, statistically significant interaction

comparisons based on the planned comparisons are included where appropriate. Tables containing means (M) and standard deviations (SD) are included in the text; tables containing results of analyses-of-variance, planned orthogonal comparisons, and significant interaction comparisons are located in Appendix F.

Hull Orientation. Results of analyses on the judgmental errors committed by soldiers in specifying the orientation of the Hull are as follows. Means (M) and standard deviations (SD) for errors in judging Hull orientation are presented in Table 1 as a function of Icon, Tank Mode, and Target Range. The results of the three-way mixed-factorial analysis-of-variance and the planned orthogonal comparisons are reported in Table F-1. Also included in Table F-1 are statistically significant interaction comparisons. The results from Table F-1 indicate no three-way interaction of Icon, Tank Mode, and Target Range. Furthermore, there are no two-way interactions involving Target Range and no main effect of Target Range. Thus, in general, Target Range did not contribute to errors in judging Hull orientation. However, there is an interaction between Icon and Tank Mode; thus, the main effects of Icon and Tank Mode cannot be interpreted directly. An examination of the interaction comparisons indicates that the C-G X Tank Mode interaction comparison is not significant; however, the A-H X Tank Mode interaction comparison is significant, and the AH-CG X Tank Mode interaction comparison is marginally significant. These results indicate that the C-G difference in errors is consistent across Tank Mode, but that the A-H and the AH-CG differences in errors are not. Thus, the planned C-G comparison can be interpreted directly, but the A-H and AH-CG comparisons cannot. An examination of the C-G comparison from Table F-1 indicates no significant difference in errors between the CITV Stationary and Main Gun Stationary Icon Groups across Tank Mode and Target Range.

Post hoc analyses were conducted to determine the source of the A-H X Tank Mode and AH-CG X Tank Mode interaction comparisons. Tukey's Honestly Significant Difference (HSD) test (for a description see Kirk, 1968) revealed that the All Moving Icon resulted in less error than did the Hull Stationary Icon in the moving tank condition ($p < .05$), but that the A-H difference was not significant in the stationary tank condition. A Scheffe test (for a description see Kirk, 1968) revealed that the combined All Moving and Hull Stationary Icon Groups exhibited less error than did the combined CITV Stationary and Main Gun Stationary Icon Groups in the moving tank condition ($p < .05$), but that the AH-CG difference was not significant in the stationary tank condition.

Table 1

Means (M) and Standard Deviations (SD) of Errors in Judging Hull Orientation as a Function of Icon Group, Tank Mode, and Target Range.

Icon Group (Ns = 11)	Condition			
	Stat/Short	Stat/Long	Mov/Short	Mov/Long
All Moving				
M	.000	.000	.182	.091
SD	.000	.000	.405	.302
Hull Stationary				
M	.000	.000	.727	.909
SD	.000	.000	.905	.944
CITV Stationary				
M	.000	.091	1.182	.818
SD	.000	.302	.751	.874
Gun Stationary				
M	.091	.091	.636	.727
SD	.302	.302	.674	.786

Note. Stat and mov refer to stationary tank and moving tank; short and long refer to short-range and long-range targets.

CITV Orientation. Results of analyses on judgmental errors committed by soldiers in specifying the orientation of the CITV are as follows. Means (M) and standard deviations (SD) for errors in judging CITV orientation are presented in Table 2 as a function of Icon, Tank Mode, and Target Range. The results of the three-way mixed-factorial analysis-of-variance and the planned orthogonal comparisons are reported in Table F-2. Also included in Table F-2 are statistically significant interaction comparisons. The results in Table F-2 indicate that there is no three-way interaction and no two-way Tank Mode X Target Range interaction. However, both two-way interactions involving Icon are marginally significant. Thus, none of the main effects can be interpreted directly. An examination of the interaction comparisons indicates that the AH-CG X Tank Mode and AH-CG X Target Range interaction comparisons are not significant. Thus, the planned AH-CG comparison can be interpreted directly. However, the significant two-way A-H X Tank Mode and A-H X Target Range interaction comparisons and the marginally significant C-G X Target Range interaction comparison indicate that the A-H and C-G comparisons cannot be interpreted directly. The significant AH-CG comparison indicates that the combined All Moving and Hull Stationary Icon Groups exhibited less error than did the combined CITV Stationary and Main Gun Stationary Icon Groups across Tank Mode and Target Range.

Table 2

Means (M) and Standard Deviations (SD) of Errors in Judging CITV Orientation as a Function of Icon Group, Tank Mode, and Target Range.

Icon Group (Ns = 11)	Condition			
	Stat/Short	Stat/Long	Mov/Short	Mov/Long
All Moving				
M	.182	.182	.727	.273
SD	.405	.405	.786	.467
Hull Stationary				
M	.091	.000	.727	1.273
SD	.302	.000	.647	.786
CITV Stationary				
M	.182	.182	1.182	.636
SD	.405	.405	.603	.809
Gun Stationary				
M	.545	.818	1.091	1.091
SD	.820	.751	.831	.701

Note. Stat and mov refer to stationary tank and moving tank; short and long refer to short-range and long-range targets.

In order to determine the source of the significant interaction comparisons, post hoc analyses were conducted with Tukey's HSD test. Analysis of the A-H X Tank Mode interaction comparison indicated significantly ($p < .05$) less error for the All Moving Icon Group than for the Hull Stationary Icon Group with a moving tank, but no difference in errors with a stationary tank. Analysis of the A-H X Target Range interaction comparison indicated significantly ($p < .05$) less error for the All Moving Icon Group than for the Hull Stationary Icon Group with long-range targets, but no difference in errors with short-range targets. Analysis of the C-G X Target Range interaction comparison indicated that the CITV Stationary Icon resulted in less error than did the Main Gun Stationary Icon with long-range targets ($p < .05$), but not with short-range targets.

Main Gun Orientation. Results of analyses on judgmental errors committed by soldiers in specifying the orientation of the Main Gun are as follows. Means (M) and standard deviations (SD) for errors in judging Main Gun orientation are presented in Table 3 as a function of Icon, Tank Mode, and Target Range. The results of the three-way mixed-factorial analysis-of-variance and the planned orthogonal comparisons are reported in Table F-3. Also included in Table F-3 are statistically significant interaction comparisons. The results from Table F-3 indicate no three-way interaction, no two-way Tank Mode X Target Range

interaction, but significant Icon X Tank Mode and Icon X Target Range interactions. Thus, none of the main effects can be interpreted directly. An examination of the interaction comparisons reveals (a) no significant interactions involving the AH-CG comparison, but (b) significant A-H X Tank Mode, A-H X Target Range, and C-G X Tank Mode interactions. Thus, the AH-CG planned comparison can be interpreted directly, but the A-H and C-G comparisons cannot. The result of the AH-CG comparison indicates no difference in errors between the combined All Moving and Hull Stationary Icon Groups and the combined CITV and Main Gun Stationary Icon Groups across Tank Mode and Target Range.

Table 3

Means (M) and Standard Deviations (SD) of Errors in Judging Main Gun Orientation as a Function of Icon Group, Tank Mode, and Target Range.

	Condition			
Icon Group (Ns = 11)	Stat/Short	Stat/Long	Mov/Short	Mov/Long
All Moving				
M	.455	.364	.727	.182
SD	.688	.505	.786	.405
Hull Stationary				
M	.091	.545	.909	1.455
SD	.302	.688	.944	.934
CITV Stationary				
M	.455	.273	1.364	.909
SD	.522	.467	.809	.831
Gun Stationary				
M	.545	.455	.545	.636
SD	.522	.522	.688	.674

Note. Stat and mov refer to stationary tank and moving tank; short and long refer to short-range and long-range targets.

Post hoc analyses of the significant interaction comparisons were conducted using Tukey's HSD test. Analysis of the A-H X Tank Mode interaction comparison indicated less error for the All Moving Icon than for the Hull Stationary Icon in the moving tank condition ($p < .05$), but not in the stationary tank condition. Analysis of the A-H X Target Range interaction revealed less error for the All Moving Icon than for the Hull Stationary Icon with long-range targets ($p < .05$), but not with short-range targets. Finally, analysis of the C-G X Tank Mode interaction indicated less error for the Main Gun Stationary Icon than for the CITV Stationary Icon in the moving tank condition ($p < .05$), but no difference in errors in the stationary tank condition.

Summary. The results of analyses of the position deviation measures can be summarized as follows: On average, soldiers in the All Moving and Hull Stationary Icon Groups were more accurate than soldiers in the CITV Stationary and Main Gun Stationary Icon Groups in judging the orientation of the CITV and in judging Hull orientation with a moving tank; however, there was no difference in accuracy when judging Main Gun orientation. Soldiers in the All Moving Icon Group were more accurate than soldiers in the Hull Stationary Icon Group in judging (a) Hull orientation with a moving tank, (b) CITV orientation with a moving tank or with long-range targets, and (c) Main Gun orientation with a moving tank or with long-range targets. Soldiers in the CITV Stationary Icon Group were more accurate than soldiers in the Main Gun Stationary Icon Group when judging CITV orientation with long-range targets; however, accuracy for these two groups was reverse when judging Main Gun orientation with a moving tank. In addition, there was no difference in accuracy between the CITV Stationary and Main Gun Stationary Icon Groups in judging Hull orientation. Finally, note that (a) in no situation was the average performance of the combined CITV Stationary and Main Gun Stationary Icon Groups superior to that of the combined All Moving and Hull Stationary Icon Groups and (b) in no situation was performance of the Hull Stationary Icon Group superior to that of the All Moving Icon Group.

The importance of these findings is even more evident when consideration is given to the practical implications of the results. Note that, although the mean position deviation errors reported in Tables 1, 2, and 3 are somewhat low in the context of the range of possible values (0 to 8), a position deviation error of only 1 point on the 0-to-8 scoring scale corresponds to an error of 22.5 degrees in judging the orientation of the Hull, CITV, or Main Gun. In fact, the field of view with the CITV set at 3-power magnification is approximately 16 degrees, yet this 16-degree field of view is considered adequate for most purposes served by the CITV (the other option is 10-power magnification, designed for close inspection of suspected enemy targets). Thus, an error of only .75 on the 0-to-8 scoring scale is equivalent in degrees (16.875) to the difference in having something in the CITV field of view versus out of the CITV field of view. Therefore, even though differences between mean errors associated with the different icons may not appear to be large, the differences reported above are not trivial.

Confidence Ratings

The confidence ratings measure the tank commander's degree of confidence in judgments of the orientations of the Hull, CITV, and Main Gun, respectively (higher numbers indicate greater confidence). The data were analyzed using three-way mixed-factorial analyses-of-variance and planned orthogonal comparisons. Tank Mode and Target Range are within-subjects factors, and Icon is a between-subjects factor. The planned orthogonal comparisons involve AH-CG, A-H, and C-G Icon Group differences in confidence ratings. Tables containing means (M)

and standard deviations (SD) are included in the text; tables containing results of analyses-of-variance, planned orthogonal comparisons, and significant interaction comparisons are located in Appendix F.

Hull Orientation. Results of analyses on the confidence soldiers expressed in their judgments of the orientation of the Hull are as follows. Means (M) and standard deviations (SD) of confidence ratings for judgments of Hull orientation are presented in Table 4 as a function of Icon, Tank Mode, and Target Range. The results of the three-way mixed-factorial analysis-of-variance and the planned orthogonal comparisons are reported in Table F-4. Also included in Table F-4 Are statistically significant interaction comparisons. The results in Table F-4 indicate no three-way interaction and no two-way Icon X Target Range or Tank X Target Range interactions; however, there is a significant Icon X Tank Mode interaction. Thus, the main effects of Icon and Tank Mode cannot be interpreted directly. An examination of the interaction comparisons involving Icon Groups and Tank Mode reveals that the A-H X Tank Mode and C-G X Tank Mode interaction comparisons are significant and that the AH-CG X Tank Mode interaction is marginally significant. Thus, none of the planned comparisons can be interpreted directly.

Table 4

Means (M) and Standard Deviations (SD) of Confidence Ratings for Judgments of Hull Orientation as a Function of Icon Group, Tank Mode, and Target Range.

	Condition			
Icon Group (Ns = 11)	Stat/Short	Stat/Long	Mov/Short	Mov/Long
All Moving				
M	5.00	4.36	4.36	4.36
SD	.000	.809	.674	.674
Hull Stationary				
M	4.82	4.91	3.73	3.64
SD	.405	.302	.905	.674
CITV Stationary				
M	4.82	4.82	3.27	3.18
SD	.405	.405	.905	1.079
Gun Stationary				
M	4.36	4.36	3.36	3.64
SD	.809	.809	.809	1.027

Note. Stat and mov refer to stationary tank and moving tank; short and long refer to short-range and long-range targets.

The A-H X Tank Mode and C-G X Tank Mode interaction comparisons were analyzed using Tukey's HSD test, and the AH-CG interaction comparison was analyzed using Scheffe's test. The results of the Scheffe tests between the combined All Moving and Hull Stationary Icon Groups versus the combined CITV Stationary and Main Gun Stationary Icon Groups indicated (a) no difference in confidence ratings with a stationary tank but (b) significantly ($p < .05$) higher confidence ratings for the combined All Moving and Hull Stationary Icon Groups than for the combined CITV Stationary and Main Gun Stationary Icon Groups with a moving tank. The results of the Tukey tests of the A-H and C-G differences in confidence ratings as a function of Tank Mode indicated (a) no difference between the All Moving Icon Group and the Hull Stationary Icon Group with a stationary tank, (b) significantly ($p < .05$) higher confidence ratings for the All Moving Icon Group than for the Hull Stationary Icon Group with a moving tank, and (c) no difference in confidence ratings between the CITV Stationary and Main Gun Stationary Icon Groups with either a stationary tank or a moving tank. This last finding of a marginally significant C-G X Tank Mode interaction comparison with no significant C-G differences in either the stationary tank or moving tank conditions can be attributed to the fact that the C-G difference is opposite in the two Tank Mode conditions. Thus, the difference is not significant in either Tank Mode condition, but the difference in the differences (which is what the interaction comparison tests) is significant. Note also that the significance of the interaction comparison was assessed with a relatively powerful test, whereas the post hoc analyses were conducted with a less powerful test.

CITV Orientation. Results of analyses on the confidence soldiers expressed in their judgments of the orientation of the CITV are as follows. Means (M) and standard deviations (SD) of confidence ratings for judgments of CITV orientation are presented in Table 5 as a function of Icon, Tank Mode, and Target Range. The results of the three-way mixed-factorial analysis-of-variance and the planned orthogonal comparisons are reported in Table F-5. Also included in Table F-5 are statistically significant interaction comparisons. The results reported in Table F-5 indicate no three-way interaction and no two-way interactions involving Icon; however, there is a significant Tank Mode X Target Range interaction and a marginally significant A-H X Tank Mode interaction comparison. Thus, neither the main effect of Tank nor the A-H planned comparison can be interpreted directly; however, the AH-CG and C-G planned comparisons can be interpreted. The results of the planned comparisons indicate (a) no difference in confidence ratings between the CITV Stationary and Main Gun Stationary Icon Groups, but (b) significantly higher confidence ratings for the combined All Moving and Hull Stationary Icon Groups than for the combined CITV Stationary and Main Gun Stationary Icon Groups.

Table 5

Means (M) and Standard Deviations (SD) of Confidence Ratings for Judgments of CITV Orientation as a Function of Icon Group, Tank Mode, and Target Range.

	Condition			
Icon Group (Ns = 11)	Stat/Short	Stat/Long	Mov/Short	Mov/Long
All Moving				
M	4.73	4.27	4.09	4.46
SD	.467	.786	.701	.688
Hull Stationary				
M	4.64	4.46	3.73	3.73
SD	.674	.820	.786	.786
CITV Stationary				
M	4.46	4.36	3.46	3.55
SD	.688	.674	.934	.934
Gun Stationary				
M	4.00	3.91	3.36	3.55
SD	.775	.831	.505	.934

Note. Stat and mov refer to stationary tank and moving tank; short and long refer to short-range and long-range targets.

The Tank Mode X Target Range interaction and the A-H X Tank Mode interaction comparison were analyzed using Tukey's HSD test. The results of the analysis of the Tank Mode X Target Range interaction indicated significantly ($p < .05$) higher confidence ratings with a stationary tank than with a moving tank in both short-range and long-range target conditions. Thus, the difference in confidence ratings between stationary versus moving tanks is significant in both Target Range conditions, but the difference is greater with short-range targets than with long-range targets. Analysis of the A-H X Tank Mode interaction comparison indicated no significant difference between the All Moving and Hull Stationary Icon Groups in either the stationary tank or moving tank conditions. This last finding of a marginally significant A-H X Tank Mode interaction comparison with no significant A-H difference in either the stationary tank or moving tank conditions can be attributed to the fact that the A-H difference is opposite in the two Tank Mode conditions. Thus, the difference is not significant in either condition, but the difference in the differences is significant. Again, note that the post hoc test is less powerful than the one used to test the interaction comparison.

Main Gun Orientation. Results of analyses on the confidence soldiers expressed in their judgments of the orientation of the Main Gun are as follows. Means (M) and standard deviations (SD)

of confidence ratings for judgments of Main Gun orientation are presented in Table 6 as a function of Icon, Tank Mode, and Target Range. The results of the three-way mixed-factorial analysis-of-variance and the planned orthogonal comparisons are reported in Table F-6. Also included in Table F-6 are statistically significant interaction comparisons. The results in Table F-6 indicate no three-way interaction and no two-way interactions involving Target Range; however, there is a significant Icon X Tank Mode interaction and a significant A-H X Tank Mode interaction comparison. Thus, neither the main effect of Tank Mode nor the A-H planned comparison can be interpreted directly. However, the AH-CG and C-G planned comparisons can be interpreted. The marginally significant AH-CG comparison indicates that confidence ratings tended to be higher in the combined All Moving and Hull Stationary Icon Groups than in the combined CITV Stationary and Main Gun Stationary Icon Groups. The nonsignificant C-G comparison indicates that there were no significant differences in confidence ratings between the CITV Stationary and Main Gun Stationary Icon Groups.

Table 6

Means (M) and Standard Deviations (SD) of Confidence Ratings for Judgments of Main Gun Orientation as a Function of Icon Group, Tank Mode, and Target Range.

	Condition			
Icon Group (Ns = 11)	Stat/Short	Stat/Long	Mov/Short	Mov/Long
All Moving				
M	4.27	4.09	4.18	4.18
SD	.905	.944	.751	.874
Hull Stationary				
M	4.56	4.46	3.73	3.55
SD	.522	.820	1.009	.934
CITV Stationary				
M	4.27	4.27	3.27	3.46
SD	.786	.647	.905	.934
Gun Stationary				
M	4.00	3.91	3.36	3.64
SD	.775	.831	.505	1.027

Note. Stat and mov refer to stationary tank and moving tank; short and long refer to short-range and long-range targets.

The significant A-H X Tank Mode interaction comparison was further analyzed using Tukey's HSD test. The results indicate no difference in confidence ratings between the All Moving and Hull Stationary Icon Groups with a stationary tank or with a moving

tank. Again, the likely reason for the finding of a significant A-H X Tank Mode interaction comparison with no significant A-H differences in either Tank Mode condition is that the A-H differences in confidence ratings are opposite in the two Tank Mode conditions. However, a contributing factor to the apparent discrepancy in findings could be the difference in power between the test used to assess the significance of the interaction comparison and the test used for the post hoc analysis of the interaction comparison.

Summary. The results of analyses of the confidence ratings can be summarized as follows: On average, soldiers in the All Moving and Hull Stationary Icon Groups reported greater confidence than did soldiers in the CITV Stationary and Main Gun Stationary Icon Groups in judging CITV and Main Gun orientations and in judging Hull orientation with a moving tank. In addition, soldiers in the All Moving Icon Group reported greater confidence than did soldiers in the Hull Stationary Icon Group in judging Hull orientation with a moving tank. Finally, there were no systematic differences in confidence ratings between the CITV Stationary and Main Gun Stationary Icon Groups.

Position Differential Measures

The three position differential measures indicate the extent to which Hull-CITV, Hull-Gun, and CITV-Gun position differences in the tank commander's orientation judgments differ from the actual differences in orientation, respectively Thus, higher numbers indicate poorer performance. The data were analyzed using three-way mixed-factorial analyses-of-variance and planned orthogonal comparisons. Tank Mode and Target Range are within-subjects factors, and Icon is a between-subjects factor. The planned orthogonal comparisons involve AH-CG, A-H, and C-G Icon Group differences in confidence ratings. Tables containing means (M) and standard deviations (SD) are included in the text; tables containing results of analyses-of-variance, planned orthogonal comparisons, and significant interaction comparisons are located in Appendix F.

Hull-CITV Orientation. Results of analyses on the position differential errors for differences in Hull and CITV orientations are as follows. Means (M) and standard deviations (SD) for the Hull-CITV position differential errors are presented in Table 7 as a function of Icon, Tank Mode, and Target Range. The results of the three-way mixed-factorial analysis-of-variance and the planned comparisons are reported in Table F-7. The results in Table F-7 indicate that there were no significant interactions between the three independent variables and no significant interaction comparisons; thus, main effects and the planned comparisons involving Icon Groups can be interpreted directly. There is a main effect of Tank Mode, with less error in the stationary tank condition than in the moving tank condition. The results of the planned comparisons involving Icon Groups indicate that there was (a) no difference in errors between the combined All Moving and Hull Stationary Icon Groups and the combined CITV

Stationary and Main Gun Stationary Icon Groups, (b) no difference in errors between the All Moving and Hull Stationary Icon Groups, but (c) significantly less error in the CITV Stationary Icon Group than in the Main Gun Stationary Icon Group.

Table 7

Means (M) and Standard Deviations (SD) for Hull-CITV Position Differential Errors as a Function of Icon Group, Tank Mode, and Target Range.

	Condition			
Icon Group (Ns = 11)	Stat/Short	Stat/Long	Mov/Short	Mov/Long
All Moving				
M	.182	.182	.545	.364
SD	.405	.405	.820	.505
Hull Stationary				
M	.091	.000	.364	.727
SD	.302	.000	.674	.786
CITV Stationary				
M	.182	.091	.182	.182
SD	.404	.302	.405	.405
Gun Stationary				
M	.636	.727	.818	.727
SD	.809	.647	1.168	.905

Note. Stat and mov refer to stationary tank and moving tank; short and long refer to short-range and long-range targets.

Hull-Gun Orientation. Results of analyses on the position differential errors for differences in Hull and Main Gun orientations are as follows. Means (M) and standard deviations (SD) for the Hull-Gun position differential errors are presented in Table 8 as a function of Icon, Tank Mode, and Target Range. The results of the three-way mixed-factorial analysis-of-variance and the planned comparisons are reported in Table F-8. Also included in Table F-8 are statistically significant interaction comparisons. The results in Table F-8 indicate that the only significant interaction is between Icon and Target Range. Thus, the main effect of Tank can be interpreted directly, but the main effects of Icon and Target Range cannot. The significant main effect of Tank indicates significantly less error with a stationary tank than with a moving tank. An examination of the interaction comparisons involving the Icon X Tank Mode and Icon X Target Range interaction comparisons reveals (a) significant A-H X Tank Mode and A-H X Target Range interaction comparisons, (b) no significant AH-CG X Tank Mode or AH-CG X Target Range interaction comparisons, and (c) no

significant C-G X Tank Mode or C-G X Target Range interaction comparisons. Thus, the planned AH-CG and C-G comparisons can be interpreted directly. The results of these two comparisons indicate that neither difference is significant; thus, there is (a) no difference in errors between the combined All Moving and Hull Stationary Icon Groups and the combined CITV Stationary and Main Gun Stationary Icon Groups and (b) no difference in errors between the CITV Stationary and Main Gun Stationary Icon Groups.

Table 8

Means (M) and Standard Deviations (SD) for Hull-Gun Position Differential Errors as a Function of Icon Group, Tank Mode, and Target Range.

	Condition			
Icon Group (Ns = 11)	Stat/Short	Stat/Long	Mov/Short	Mov/Long
All Moving				
M	.455	.364	.545	.091
SD	.688	.505	.820	.302
Hull Stationary				
M	.091	.545	.545	1.091
SD	.302	.688	.522	.701
CITV Stationary				
M	.455	.364	.545	.636
SD	.522	.505	.820	.674
Gun Stationary				
M	.455	.364	.818	.455
SD	.522	.505	.751	.522

Note. Stat and mov refer to stationary tank and moving tank; short and long refer to short-range and long-range targets.

The significant A-H X Tank Mode and A-H X Target Range interaction comparisons were further analyzed using Tukey's HSD test. The results indicate that there is (a) no difference in errors between the All Moving and Hull Stationary Icon Groups with a stationary tank, (b) significantly ($p < .05$) less error for the All Moving Icon Group than for the Hull Stationary Icon Group with a moving tank, (c) no difference in errors between the All Moving and Hull Stationary Icon Groups with short-range targets, and (d) significantly ($p < .05$) less error for the All Moving Icon Group than for the Hull Stationary Icon Group with long-range targets.

CITV-Gun Orientation. Results of analyses on the position differential errors for differences in CITV and Main Gun orientations are as follows. Means (M) and standard deviations

(SD) for the CITV-Gun position differential errors are presented in Table 9 as a function of Icon, Tank Mode, and Target Range. The results of the three-way mixed-factorial analysis-of-variance and the planned comparisons are reported in Table F-9. Also included in Table F-9 are statistically significant interaction comparisons. The results in Table F-9 indicate no three-way interaction, no two-way interaction between Tank Mode and Target Range or between Icon and Tank Mode, but a marginally significant Icon X Target Range interaction and significant A-H X Tank Mode and A-H X Target Range interaction comparisons. Thus, the AH-CG and C-G planned comparisons can be interpreted directly, but the A-H comparison cannot. The results of the planned AH-CG and C-G comparisons indicate that neither was significant. Thus, errors did not differ for the CITV Stationary and Main Gun Stationary Icon Groups, and errors for the combined All Moving and Hull Stationary Icon Groups did not differ from errors for the combined CITV Stationary and Main Gun Stationary Icon Groups.

Table 9

Means (M) and Standard Deviations (SD) for CITV-Gun Position Differential Errors as a Function of Icon Group, Tank Mode, and Target Range.

	Condition			
Icon Group (Ns = 11)	Stat/Short	Stat/Long	Mov/Short	Mov/Long
All Moving				
M	.636	.364	.545	.273
SD	.924	.505	.688	.467
Hull Stationary				
M	.182	.545	.727	1.091
SD	.603	.688	.786	1.044
CITV Stationary				
M	.636	.455	.545	.636
SD	.505	.688	.688	.809
Gun Stationary				
M	.727	.909	.909	.455
SD	.647	.831	.831	.688

Note. Stat and mov refer to stationary tank and moving tank; short and long refer to short-range and long-range targets.

The significant interaction comparisons involving the A-H planned comparison were analyzed using Tukey's HSD test. Analysis of the A-H X Tank Mode interaction comparison indicates no difference in errors between the All Moving and Hull Stationary Icon Groups with a stationary tank, but significantly

($p < .05$) less error for the All Moving Icon Group than for the Hull Stationary Icon Group with a moving tank. Analysis of the A-H X Target Range interaction comparison indicates no difference in errors between the All Moving and Hull Stationary Icon Groups with short-range targets, but significantly ($p < .05$) less error for the All Moving Icon Group than for the Hull Stationary Icon Group with long-range targets.

Summary. The results of analyses of the position differential errors can be summarized as follows: On average, there was no difference in errors between soldiers in the All Moving and Hull Stationary Icon Groups and soldiers in the CITV Stationary and Main Gun Stationary Icon Groups. However, performance of soldiers in the All Moving Icon Group was superior to that of soldiers in the Hull Stationary Icon Group for Hull-Gun and CITV-Gun position differential errors with a moving tank and with long-range targets. Finally, performance of soldiers in the CITV Stationary Icon Group was superior to that of soldiers in the Main Gun Stationary Icon Group for Hull-Gun position differential errors. As with the position deviation measures, an appreciation of the practical significance of these results can be achieved by noting that a 1-point position differential error corresponds to a difference of 22.5 degrees.

Out-of-Sector Detection Scores

Table 10 contains means (M) and standard deviations (SD) for detections of out-of-sector scanning as a function of Icon and Target Range. The values the means (M) can assume range from 0 (indicating that none of the 11 soldiers in that icon group

Table 10

Means (M) and Standard Deviations (SD) for Detection of Out-of-Sector Scanning as a Function of Icon Group and Target Range.

	Icon Group			
Condition	All Moving (N = 11)	Hull Stat (N = 11)	CITV Stat (N = 11)	Gun Stat (N = 11)
Stat/Short				
M	.455	.818	.636	.727
SD	.522	.405	.505	.467
Stat/Long				
M	.455	.818	.636	.636
SD	.522	.405	.505	.505

Note. Stat refers to stationary tank when indicating a condition and refers to stationary icon part when describing an icon; short and long refer to short-range and long-range targets.

detected the out-of-sector scanning in that condition) to 1 (indicating that all of the 11 soldiers in that icon group detected the out-of-sector in that condition). Two-way mixed-factorial analysis-of-variance results are reported in Table 11. Icon is a between-subjects factor, and Target Range is a within-subjects factor. Also included are the results of the planned orthogonal comparisons involving AH-CG, A-H, and C-G Icon Group differences.

The results in Table 11 indicate no interaction between Icon and Target Range. Therefore, the main effects of Icon and Target Range can be interpreted directly. In addition, there are no significant interaction comparisons. Thus, the planned orthogonal comparisons can be interpreted directly. As can be ascertained from an examination of the results, there are no main effects of Icon or Target Range. Furthermore, only the A-H planned comparison is significant. An examination of the means from Table 10 indicates that there were fewer detections of out-of-sector scanning in the All Moving Icon Group than in the Hull Stationary Icon Group.

Table 11

Analysis-of-Variance Results for Detection of Out-of-Sector Scanning as a Function of Icon and Target Range.

Source	df	SS	MS	F
Icon	3	1.49	.50	1.52
AH-CG	1	.01	.01	<1.00
A-H	1	1.45	1.45	4.44**
C-G	1	.02	.02	<1.00
Error (S/Icon)	40	13.09	.33	
Target Range	1	.01	.01	<1.00
Icon X Target Range	3	.03	.01	<1.00
Error (S/Icon X Target Range)	40	5.45	.14	
Total	87	20.07		

Note. AH-CG indicates a comparison of All Moving and Hull Stationary Icon Groups with CITV Stationary and Gun Stationary Icon Groups; A-H indicates a comparison between the All Moving and Hull Stationary Icon Groups; C-G indicates a comparison between the CITV Stationary and Gun Stationary Icon Groups.

** $p < .05$.

Summary. The results of the analysis on detections of out-of-sector scanning can be summarized as follows: On average, there was no difference in performance between (a) soldiers in the combined All Moving and Hull Stationary Icon Groups and soldiers in the combined CITV Stationary and Main Gun Stationary Icon Groups and (b) soldiers in the CITV Stationary Icon Group and soldiers in the Main Gun Stationary Icon Group. However, performance of soldiers in the Hull Stationary Icon Group was superior to that of soldiers in the All Moving Icon Group.

Out-of-Sector Detection Times

The analysis of the out-of-sector detection times presents a special problem. Not all participants detected the out-of-sector scanning in both of the Target Range conditions; therefore, only those who did detect the out-of-sector scanning have actual detection times. One of the following two options typically is selected as a solution to this problem: (a) analyze the scores for only those individuals who have actual detection times and (b) assign the highest possible score to those individuals for whom a score is not available.

The advantage of the former approach is that only actual detection times are analyzed. The disadvantages are (a) an unbalanced design (i.e., sample sizes are not equal) due to "missing" detection times for some soldiers and (b) a loss of error degrees of freedom, resulting in a potential reduction in statistical power to detect genuine differences in group performances. The advantages of the latter approach are (a) a balanced design is maintained and (b) there is no loss of error degrees of freedom. The justification for this approach in this situation is that the gunner scanned out of sector for 30 seconds; thus, those individuals who did not detect the out-of-sector scanning failed to do so for the full 30 seconds. The disadvantage of this approach is that soldiers who do not have an actual score now receive the same score; thus, any individual differences in actual performance are artificially masked by the somewhat arbitrary assignment of the same score to these soldiers. That is, if the gunner had been able to scan out of sector for a longer period of time, some of these soldiers likely would have detected it before others, and therefore would not have received the same score. The decision was made to analyze the data using both approaches and to reconcile any differences in results afterward.

Table 12 contains means (M) and standard deviations (SD) of out-of-sector detection times (in seconds) as a function of Icon and Target Range for those soldiers who detected the out-of-sector scanning. An unweighted-means analysis-of-variance was used to analyze these data (for a description see Kirk, 1968). The results of the two-way mixed-factorial unweighted-means analysis-of-variance are reported in Table 13. Icon is a between-subjects factor, and Target Range is a within-subjects factor. Also included are the results of the planned comparisons involving AH-CG, A-H, and C-G Icon Group differences.

Table 12

Means (M) and Standard Deviations (SD) of Time (sec) to Detect Out-of-Sector Scanning as a Function of Icon Group and Target Range for Soldiers who Detected Out-of-Sector Scanning.

	Icon Group			
Condition	All Moving (N = 3)	Hull Stat (N = 7)	CITV Stat (N = 6)	Gun Stat (N = 7)
Stat/Short				
M	13.00	9.29	13.00	12.86
SD	9.85	6.55	8.67	8.32
Stat/Long				
M	19.33	7.43	15.33	7.71
SD	8.39	3.12	7.74	5.35

Note. Stat refers to stationary tank when indicating a condition and refers to stationary icon part when describing an icon; short and long refer to short-range and long-range targets.

Table 13

Unweighted-Means Analysis-of-Variance Results for Time to Detect Out-of-Sector Scanning as a Function of Icon and Target Range.

Source	df	SS	MS	F
Icon	3	374.91	124.97	2.05
AH-CG	1	.01	.01	<1.00
A-H	1	256.15	256.15	4.21*
C-G	1	97.32	97.32	1.60
Error (S/Icon)	19	1155.57	60.82	
Target Range	1	1.77	1.77	<1.00
Icon X Target Range	3	175.58	58.53	1.47
Error (S/Icon X Target Range)	19	757.86	39.89	

Note. AH-CG indicates a comparison of All Moving and Hull Stationary Icon Groups with CITV Stationary and Gun Stationary Icon Groups; A-H indicates a comparison between the All Moving and Hull Stationary Icon Groups; C-G indicates a comparison between the CITV Stationary and Gun Stationary Icon Groups.

* $p < .10$.

The results in Table 13 indicate no interaction between Icon and Target Range. Therefore, the main effects of Icon and Target Range can be interpreted directly. In addition, there are no significant interaction comparisons. Thus, the planned orthogonal comparisons can be interpreted directly. As can be ascertained from an examination of the results, there are no main effects of Icon or Target Range. Furthermore, the AH-CG and C-G planned comparisons are not significant, and the A-H planned comparison is only marginally significant. Examination of the means from Table 12 indicates that the out-of-sector detection time is lower in the Hull Stationary Icon Group than in the All Moving Icon Group.

Table 14 contains means (M) and standard deviations (SD) of out-of-sector detection times (in seconds) as a function of Icon and Target Range, with soldiers who did not detect the out-of-sector scanning in a condition assigned a time of 30 seconds for that condition. An appropriate analysis for these data is a standard analysis-of-variance. The results of the two-way mixed-factorial analysis-of-variance are reported in Table 15. Icon is a between-subjects factor, and Target Range is a within-subjects factor. Also included are the results of the planned orthogonal comparisons involving AH-CG, A-H, and C-G Icon Group differences.

Table 14

Means (M) and Standard Deviations (SD) of Time (sec) to Detect Out-of-Sector Scanning as a Function of Icon Group and Target Range for All Soldiers.

	Icon Group			
Condition	All Moving (N = 11)	Hull Stat (N = 11)	CITV Stat (N = 11)	Gun Stat (N = 11)
Stat/Short				
M	21.91	13.00	20.36	16.82
SD	10.31	9.91	10.51	10.89
Stat/Long				
M	23.09	14.64	19.82	15.82
SD	9.78	10.50	10.13	11.98

Note. Stat refers to stationary tank when indicating a condition and refers to stationary icon part when describing an icon; short and long refer to short-range and long-range targets.

The results in Table 15 correspond to those found using the former approach. There is no interaction between Icon and Target Range, and there are no significant interaction comparisons. Furthermore, there are no main effects of Icon or Target Range, and the AH-CG and C-G planned comparisons are not significant. However, the A-H planned comparison is significant. Examination of the means from Table 14 indicates that the out-of-sector detection time is lower in the Hull Stationary Icon Group than in the All Moving Icon Group.

Table 15

Analysis-of-Variance Results for Time to Detect Out-of-Sector Scanning as a Function of Icon and Target Range.

Source	df	SS	MS	F
Icon	3	985.73	328.50	2.19
AH-CG	1	.05	.05	<1.00
A-H	1	829.11	829.11	5.54*
C-G	1	156.57	156.57	1.05
Error (S/Icon)	40	5990.36	149.76	
Target Range	1	2.23	2.23	<1.00
Icon X Target Range	3	27.32	9.11	<1.00
Error (S/Icon X Target Range)	40	2865.45	71.64	

Note. AH-CG indicates a comparison of All Moving and Hull Stationary Icon Groups with CITV Stationary and Gun Stationary Icon Groups; A-H indicates a comparison of the All Moving Icon Group with the Hull Stationary Icon Group; C-G indicates a comparison between the CITV Stationary Icon Group and the Gun Stationary Icon Group.

* $p < .10$.

Summary. The results of the analyses on time to detect out-of-sector scanning can be summarized as follows: On average, there was no difference in performance between (a) soldiers in the All Moving and Hull Stationary Icon Groups and soldiers in the CITV Stationary and Main Gun Stationary Icon Groups and (b) soldiers in the CITV Stationary Icon Group and soldiers in the Main Gun Stationary Icon Group. However, performance of soldiers in the Hull Stationary Icon Group was superior to that of soldiers in the All Moving Icon Group.

Orientation Indicator Questionnaire Items

Item 1 asked soldiers to rank order the Hull, CITV, and Main Gun in terms of how important they considered knowledge of the orientation to be. The medians across Icon Groups for the three components are 2.50 for the Hull orientation, 2.07 for the CITV orientation, and 1.70 for the Main Gun orientation. Thus, in general, soldiers tended to consider knowledge of the Main Gun orientation to be most important and knowledge of the Hull orientation to be least important.

Means (M) and standard deviations (SD) for select items (2a, 2b, and 2c) that asked soldiers to indicate the difficulty in determining the orientations of the CITV, Hull, and Main Gun using a 5-point scale (higher number indicates greater difficulty) are reported in Table 16. One-way analysis-of-variance results, with Icon as the between-subjects factor, are reported in Table 17. Also included are the results of planned orthogonal comparisons involving the AH-CG, A-H, and C-G Icon Group differences.

Table 16

Means (M) and Standard Deviations (SD) for Select Orientation Indicator Questionnaire Items that Assessed Reported Difficulty in Judging CITV, Hull, and Main Gun Orientations as a Function of Icon Group.

		Icon Group			
Item Number:	Measure	All Moving (N = 11)	Hull Stat (N = 11)	CITV Stat (N = 11)	Gun Stat (N = 11)
2a.	Reported Difficulty Judging CITV Orientation				
	M	2.46	1.82	2.55	3.18
	SD	.93	.75	1.29	1.08
2b.	Reported Difficulty Judging Hull Orientation				
	M	2.46	3.73	3.91	3.91
	SD	.93	1.10	1.58	1.14
2c.	Reported Difficulty Judging Main Gun Orientation				
	M	2.27	1.82	2.36	3.36
	SD	.90	.75	1.03	1.29

Note. Stat refers to the stationary part of the icon.

The results from Table 17 indicate a significant main effect of Icon for responses to each of the three items that pertain to difficulty in indicating the CITV, Hull, and Main Gun positions. Results of the planned comparisons indicate that (a) the AH-CG

Table 17

Between-Subjects Analysis-of-Variance Results for Select Orientation Indicator Questionnaire Items that Assessed Reported Difficulty in Judging CITV, Hull, and Main Gun Orientations as a Function of Icon.

Source	df	SS	MS	F
Dependent Variable: Reported CITV Orientation Difficulty				
Icon	3	10.27	3.42	3.21**
AH-CG	1	5.82	5.82	5.45**
A-H	1	2.23	2.23	2.08
C-G	1	2.23	2.23	2.08
Error (S/Icon)	40	42.73	1.07	
Dependent Variable: Reported Hull Orientation Difficulty				
Icon	3	16.27	5.42	3.70**
AH-CG	1	7.36	7.36	5.02**
A-H	1	8.91	8.91	6.07**
C-G	1	0.00	0.00	<1.00
Error (S/Icon)	40	58.73	1.47	
Dependent Variable: Reported Main Gun Orientation Difficulty				
Icon	3	14.00	4.67	4.56**
AH-CG	1	7.36	7.36	7.20**
A-H	1	1.14	1.14	1.11
C-G	1	5.50	5.50	5.38**
Error (S/Icon)	40	40.91	1.02	

Note. AH-CG indicates a comparison of the All Moving and Hull Stationary Icon Groups with the CITV Stationary and Gun Stationary Icon Groups; A-H indicates a comparison of the All Moving Icon Group with the Hull Stationary Icon Group; C-G indicates a comparison between the CITV Stationary Icon Group and the Gun Stationary Icon Group.

** $p < .05$.

difference is significant for all three measures, (b) the A-H difference is significant for difficulty in judging the position of the Hull, and (c) the C-G difference is significant for judging the orientation of the Main Gun. An examination of the means from Table 16 indicates that (a) soldiers in the CITV Stationary and Main Gun Stationary Icon Groups reported more difficulty in judging the orientations of the CITV, Hull, and Main Gun than did soldiers in the All Moving and Hull Stationary Icon Groups, (b) soldiers in the Hull Stationary Icon Group reported more difficulty in judging the orientation of the Hull than did soldiers in the All Moving Icon Group, and (c) soldiers in the Main Gun Stationary Icon Group reported more difficulty in determining the orientation of the Main Gun than did soldiers in the CITV Stationary Icon Group.

Table 18 is a contingency table of responses to Item 4 of the Orientation Indicator Questionnaire, which asked soldiers to indicate if the icon they used should be retained or should be changed to one of the other three icons. These preference responses are reported separately for each Icon Group. An analysis of these data indicated that icon preference varied as a function of Icon Group ($\chi^2 = 29.55$, $df = 9$, $p < .05$). Subsequent analyses based on the planned comparisons described earlier indicated that icon preference (a) differed for the combined All Moving and Hull Stationary Icon Groups versus the combined CITV Stationary and Main Gun Stationary Icon Groups ($\chi^2 = 13.68$, $df = 3$, $p < .05$), (b) differed for the CITV and Main Gun Stationary Icon Groups ($\chi^2 = 8.67$, $df = 3$, $p < .05$), but (c) did not differ for the All Moving and Hull Stationary Icon Groups ($\chi^2 = .19$, $df = 1$, $p > .05$).

Table 18

Icon Preference as a Function of Icon Group.

	Icon Choice				
Icon Group	All Moving	Hull Stat	CITV Stat	Gun Stat	Total
All Moving	7	4	0	0	11
Hull Stat	6	5	0	0	11
CITV Stat	2	4	5	0	11
Gun Stat	1	8	0	2	11
Total	16	21	5	2	44

Note. Entries are the number of soldiers selecting that icon.

Several aspects of the data are noteworthy: (a) none of the soldiers in the All Moving and Hull Stationary Icon Groups recommended a change to either the CITV Stationary Icon or the Main Gun Stationary Icon; (b) seven of the 11 soldiers in the All Moving Icon Group recommended retaining the All Moving Icon, whereas the remainder recommended a change to the Hull Stationary Icon; (c) soldiers in the Hull Stationary Icon Group were about equally split in terms of recommending a change to the All Moving Icon versus retaining the Hull Stationary Icon; (d) about half of the soldiers in the CITV Stationary Icon Group recommended a change to either the All Moving or Hull Stationary Icons, and of those recommending a change, more soldiers recommended a change to the Hull Stationary Icon than to the All Moving Icon; and (e) nine of the 11 soldiers in the Main Gun Stationary Icon Group recommended a change to either the All Moving or Hull Stationary Icons, and of those recommending a change, eight soldiers recommended a change to the Hull Stationary Icon and one soldier recommended a change to the All Moving Icon.

Comments in response to Item 5, which asked soldiers to describe any problems they encountered in using the icon, and to Item 6, which asked soldiers for any recommended changes to the icon, were collated. The most common problem soldiers reported was keeping track of the Hull orientation, and the most common recommendation was to include something to indicate direction (e.g., compass, azimuth indicator, direction indicator, or direction finder). Table 19 contains the number of soldiers reporting the problem and the number of soldiers who recommended including a device to indicate direction as a function of Icon

Table 19

Number of Soldiers Reporting Problem Keeping Track of Hull Orientation and Number of Soldiers Recommending Inclusion of a Direction Indicator with the Icon as a Function of Icon Group.

		Icon Group			
Item Number:	Measure	All Moving (N = 11)	Hull Stat (N = 11)	CITV Stat (N = 11)	Gun Stat (N = 11)
5.	Reported problem keeping track of hull orientation	0	6	8	7
6.	Recommended inclusion of direction indicator	3	5	6	4

Note. Stat refers to the stationary part of the icon.

Group. The problem was not uniformly reported across Icon Groups ($\chi^2 = 14.12$, df = 3, $p < .05$), but the recommendation to include something to indicate direction tended to be uniform across Icon Groups ($\chi^2 = 1.90$, df = 3, $p > .05$). Subsequent analysis of the number of soldiers reporting the problem indicated no difference between the Hull Stationary, CITV Stationary, and Main Gun Stationary Icon Groups ($\chi^2 = 1.18$, df = 2, $p > .05$); thus, the reason for the significant effect is that soldiers in the All Moving Icon Group did not report having difficulty keeping track of the Hull orientation. On the other hand, a sufficient number of soldiers in the All Moving Icon Group recommended the inclusion of a direction indicator that there were no significant Icon Group differences. Overall, 47.7% of the soldiers indicated a problem keeping track of the Hull orientation, and 40.9% recommended inclusion of a direction indicator.

Summary. The primary results of analyses of responses to Orientation Indicator Questionnaire Items can be summarized as follows: On average, soldiers in the CITV Stationary and Main Gun Stationary Icon Groups reported greater difficulty in judging the orientations of the Hull, CITV, and Main Gun than did soldiers in the All Moving and Hull Stationary Icon Groups. In addition, soldiers in the Hull Stationary Icon Group reported greater difficulty in judging the Hull orientation than did soldiers in the All Moving Icon Group, and soldiers in the Main Gun Stationary Icon Group reported greater difficulty in judging the Main Gun orientation than did soldiers in the CITV Stationary Icon Group. Finally, soldiers tended to indicate a preference for either the All Moving or Hull Stationary Icons, with no clear preference expressed for one over the other, and tended to recommend the inclusion of a direction indicator with the icon.

Summary

As mentioned earlier, the purpose of this research project was to investigate the four alternative orientation indicators (icons) to determine which, if any, is superior in providing the tank commander with information regarding the Hull, CITV, and Main Gun orientations. Three sources of information were used to make this determination: (a) actual performance measures, (b) confidence ratings from soldiers, and (c) evaluations and recommendations from soldiers. The primary basis for comparing the icons was a set of three orthogonal comparisons: (a) All Moving and Hull Stationary Icon Groups versus CITV Stationary and Main Gun Stationary Icon Groups (AH-CG), (b) All Moving Icon Group versus Hull Stationary Icon Group (A-H), and (c) CITV Stationary Icon Group versus Main Gun Stationary Icon Group (C-G). Thus, the results will be summarized in the context of those comparisons.

The combined All Moving and Hull Stationary Icon Groups were found to be superior to the combined CITV Stationary and Main Gun Stationary Icon Groups in judging Hull orientation with a moving tank and judging CITV orientation regardless of Tank Mode or

Target Range. In addition, soldiers who used the All Moving Icon or the Hull Stationary Icon reported greater confidence in judging Hull orientation with a moving tank and in judging CITV and Main Gun orientations regardless of Tank Mode or Target Range. Furthermore, soldiers in the All Moving and Hull Stationary Icon Groups reported less difficulty in judging the Hull, CITV, and Main Gun orientations. No difference was found (a) in judging Main Gun orientation or in judging Hull orientation with a stationary tank, (b) on any of the position differential measures, (c) for either detection of out-of-sector scanning or out-of-sector detection time, and (d) in reported confidence in judging Hull orientation with a stationary tank. Finally, the combined CITV Stationary and Main Gun Stationary Icon Groups were not found to be superior to the combined All Moving and Hull Stationary Icon Groups on any measure.

The All Moving Icon Group was found to be superior to the Hull Stationary Icon Group in (a) judging Hull orientation with a moving tank, (b) judging CITV orientation with a moving tank and with long-range targets, and (c) judging Main Gun orientation with a moving tank and with long-range targets. In addition, soldiers in the All Moving Icon Group exhibited less position differential error for both Hull-Gun and CITV-Gun position differentials with a moving tank and with long-range targets. Also, soldiers reported greater confidence judging Hull orientation with a moving tank and less overall difficulty in judging Hull orientation. No difference was found (a) in judging the Hull, CITV, or Main Gun orientations when the tank was stationary, (b) in judging CITV or Main Gun orientations with short-range targets, (c) for confidence ratings in judging Hull orientation with a stationary tank, (d) in position differential errors for the Hull-CITV position differential or for the Hull-Gun and CITV-Gun position differentials with a stationary tank or with short-range targets, and (e) in reported difficulty in judging either CITV or Main Gun orientations. On the other hand, the Hull Stationary Icon Group was superior to the All Moving Icon Group in detecting out-of-sector scanning and in the time to detect the out-of-sector scanning.

There were very few differences between the CITV Stationary and Main Gun Stationary Icon Groups. For this reason and the fact that the CITV Stationary and Main Gun Stationary Icon Groups were not found to be superior to the All Moving and Hull Stationary Icon Groups on any measure, only the differences will be summarized. The CITV Stationary Icon Group was superior to the Main Gun Stationary Icon Group (a) in judging CITV orientation with long-range targets and (b) in terms of Hull-CITV position differential errors. In addition, soldiers in the CITV Stationary Icon Group reported less difficulty in judging the Main Gun orientation. However, the Main Gun Stationary Icon Group was superior to the CITV Stationary Icon Group in judging Main Gun orientation with a moving tank.

In terms of soldier evaluations and recommendations, the following results were obtained: (a) none of the soldiers in the

All Moving or Hull Stationary Icon Groups recommended a change to either the CITV Stationary or Main Gun Stationary Icons, (b) four of the 11 soldiers in the All Moving Icon Group recommended a change to the Hull Stationary Icon, whereas six of the 11 soldiers in the Hull Stationary Icon Group recommended a change to the All Moving Icon, (c) six of the 11 soldiers in the CITV Stationary Icon Group recommended a change (four to the Hull Stationary Icon and two to the All Moving Icon), (d) nine of the 11 soldiers in the Main Gun Stationary Icon Group recommended a change (eight to the Hull Stationary Icon and one to the All Moving Icon), and (e) 40.9% of the soldiers recommended inclusion of a direction indicator (e.g., compass, azimuth indicator) with the icon.

Discussion and Conclusions

In general, the results of this research project support the use of either the All Moving Icon or the Hull Stationary Icon with the CITV. However, the results do not provide unequivocal support for either the All Moving Icon or the Hull Stationary Icon over the other. The decision of which icon to use must be based on a consideration of the relative importance of the functions to be served by the icon. For example, if the Army considers minimizing position deviation errors and positional differential errors to be more important than maintaining an awareness of whether the gunner is appropriately scanning an assigned sector, the results would support the inclusion of the All Moving Icon with the CITV. However, if the priorities are the opposite, the results would support use of the Hull Stationary Icon. One possible way to reconcile this apparent dilemma would be to incorporate into the CITV the capability of selecting either the All Moving Icon or the Hull Stationary Icon. Another solution would be to use the All Moving Icon, but to include a signal (e.g., flashing light or tone) that would alert the tank commander when the gunner scanned outside of an assigned sector.

Regardless of which icon is selected, another issue must be addressed. As indicated, over 40% of the soldiers recommended including a cardinal direction indicator with the icon. Recall that the POSNAV system described in the introduction includes an icon and provides information about the cardinal orientation of the Hull and the Main Gun. Soldiers possibly could use this information instead of including a direction indicator with the CITV icon. However, there are two limitations of having soldiers use the CITV icon to obtain information about the relative orientations of the Hull, CITV, and Main Gun, but use the POSNAV icon to obtain information about the cardinal orientations of the Hull and Main Gun.

The first limitation is that the POSNAV icon used in the study by Du Bois and Smith (1989) did not include the CITV LOS as a component. One way to remedy this potential problem is simply to modify the POSNAV icon to include a component that indicates the CITV LOS. In fact, the inclusion of a CITV LOS component

with the POSNAV icon is one of the planned modifications to the prototype POSNAV system (Directorate of Combat Development, 1988). The results of this investigation support the advantage of making this modification. However, this solution might not be sufficient, because there is a second limitation.

The second limitation relates to a problem described by Dedmon and Mielec (1984), as noted in the introduction to this report: The soldiers would have to look away from the CITV screen to ascertain the cardinal directions the Hull, CITV, and Main Gun were pointed. Doing so could hinder surveillance and impair target acquisition. One solution to this problem would be to (a) have both POSNAV and CITV icons include representations of the Hull, the Main Gun, and the CITV LOS and (b) integrate the two systems (POSNAV and CITV) so that both would indicate relative and cardinal orientations of the three components (Hull, Main Gun, and CITV). The advantage of integrating the CITV and POSNAV systems and coordinating the information communicated by the two icons is that the tank commander would not have to remember or determine which icon he was viewing or the type of information he was receiving. Thus, the likelihood of confusion resulting from misinterpretation of information (e.g., basing decisions on relative orientation information when cardinal orientation information is required) would be reduced. However, in order to minimize confusion, the POSNAV and CITV icons probably should be fully compatible in terms of visual representation and orientation of components displayed on the respective screens; this compatibility would appear to be most readily achieved by using the All Moving Icon for the CITV system.

References

Black, B. A., & Quinkert, K. A. (1987, November-December). Simulation networking: A MANPRINT tool. Army Research, Development & Acquisition Bulletin, pp. 8-10.

Dedmon, J. F., & Mielec, R. (1984). Customer test of the Surrogate Research Vehicle: Phase 1B. Warren, MI: Commander, U.S. Army Tank-Automotive Command (TACOM), ATTN: DRSTA-ZEC.

Directorate of Combat Development. (1988). IVIS: Intervehicular Information System. Ft. Knox, KY: Directorate of Combat Development, United States Army Armor School.

Du Bois, R. S., & Smith, P. G. (1989). A simulation-based evaluation of a position navigation system for armor: Soldier performance, training, and functional requirements. (ARI Technical Report, in preparation). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

General Electric Company (1987). Instructor's utilization handbook for the M1 Unit-Conduct of Fire Trainer (U-COFT). Daytona Beach, FL: Simulation and Control Systems Department, General Electric Company.

General Electric Company. (1988). Commander's Independent Thermal Viewer (CITV) operator's manual. Daytona Beach, FL: Simulation and Control Systems Department, General Electric Company.

Keppel, G. (1982). Design & analysis: A researcher's handbook (2nd ed.). Englewood Cliffs, NJ: Prentice-Hall.

Kirk, R. E. (1968). Experimental design: Procedures for the behavioral sciences. Belmont, CA: Brooks/Cole.

Quinkert, K. A. (1987). Preliminary training requirements analysis for the Commander's Independent Thermal Viewer (CITV) (ARI Research Product 87-19). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A185 467)

Quinkert, K. A. (1988). Design and functional specifications for simulation of the Commander's Independent Thermal Viewer (CITV) (ARI Research Product 88-17). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A201 419)

Quinkert, K. A. (in preparation). Crew performance assessment associated with the simulation of the Commander's Independent Thermal Viewer (CITV) (ARI Technical Report). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Witmer, B. G. (1988). Effects of degraded mode gunnery procedures on the performance of M1 tank gunners (ARI Technical Report 778). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A192 246)

APPENDIX A

Biographical Questionnaire

RP#: ____ Group: ALLMOV G: _____ Date: _____ Time: _____

1. Age: _____ years _____ months.

2. Grade: E-____ .

3. Social Security Number: _____ - ___ - _____ .

4. Education. Circle one.

   a. Less than 12 years b. GED c. High School Graduate

   d. Vocational School e. Some college: _____ years

   f. College graduate g. Other (describe briefly):

   _____

   _____

5. General Technical (GT) score: _____ .

6. Total time in service: _____ years _____ months.

7. Total time in an Armor MOS: _____ years _____ months.

8. Current duty position: _____ .

9. Time in current duty position: _____ months.

10. Last tank crew position: _____ .

11. Time in last tank crew position: _____ months.

12. Last vehicle: _____ .

13. Time in last vehicle: _____ months.

14. Total time as a Tank Commander: _____ months.

    As M60 TC: _____ months.
    As M1 TC: _____ months.
    As M1A1 TC: _____ months.

15. On how many separate occasions have you fired the COFT? ____.

16. Total Hours spent on COFT: _____ hours.

APPENDIX B

Instructions

CITV Instructions

The purpose of this session is to explain why we have asked for your assistance and to familiarize you with the use of the Commander's Independent Thermal Viewer, which is called the CITV.

Recently, the U.S. Army began the Manpower and Personnel Integration program, which is called MANPRINT. MANPRINT was designed to produce better human performance and reliability in the operation, maintenance, and use of equipment and weapon systems. One aim of MANPRINT is to include the soldier in the design process early in the development of a system. One application of MANPRINT is to the Main Battle Tank Block II program. The Block II program includes several technological advances being considered as potential improvements to the original design of the M1 Tank. One major addition is the Commander's Independent Thermal Viewer. The CITV is located in front of you. The CITV provides the Tank Commander with the opportunity for independent surveillance, automatic visual scan, and automatic slewing of the Gunner's reticle to the target area.

We will now discuss the CITV switches and controls.

YOU SHOULD PERFORM THE FUNCTIONS AS I DESCRIBE THEM TO YOU.

YOU MAY ASK QUESTIONS AT ANY TIME.

The ON/OFF/STANDBY switch is located at the bottom left corner of the control panel.

When this switch is in the OFF position, the CITV system is nonfunctional. When set to the STANDBY position, a flashing green light located on the panel will illuminate to indicate "ready". When the switch is set to the ON position, all of the CITV's power will come on, and the CITV will automatically align with the Main Gun, which is the Gun Line of Sight or GLOS mode.

The MAGNIFICATION switch is located in the lower right corner of the panel.

The MAGNIFICATION switch allows you to select three power or ten power magnification of the CITV image.

The POLARITY switch is located on the right side of the control panel.

The POLARITY switch allows you to view the CITV screen in "white hot" or "black hot."

The INCREASE/YES and DECREASE/NO switches are located on the lower right of the panel, just above the MAGNIFICATION switch.

These switches, when used with other switches, allow you to make adjustments to suit your preferences for reticle and symbol brightness, contrast and sensitivity of the CITV image, and the CITV scanning rate when in the Auto Scan mode.

The CONTRAST/SENSITIVITY switch is located at the upper right corner of the panel.

Press this switch once and the word CONTRAST will illuminate. The INCREASE and DECREASE switches will also illuminate. Press the INCREASE and DECREASE switches to adjust the CONTRAST of the CITV image. Press the CONTRAST/SENSITIVITY switch a second time and the word SENSITIVITY will illuminate. Press the INCREASE and DECREASE switches to adjust the SENSITIVITY. Press the CONTRAST/SENSITIVITY switch a third time and the switch will go off.

The RETICLE/SYMBOL switch is located at the upper left corner of the panel.

Press this switch once and the word RETICLE will illuminate. The INCREASE and DECREASE switches will also illuminate. Press the INCREASE and DECREASE switches to adjust the BRIGHTNESS of the RETICLE. Press the RETICLE/SYMBOL switch a second time and the word SYMBOL will illuminate. Press the INCREASE and DECREASE switches to adjust the BRIGHTNESS of your symbols. Press the RETICLE/SYMBOL switch a third time and the switch will go off.

The GUN LINE OF SIGHT switch is located at the bottom of the control panel.

Pressing the GUN LINE OF SIGHT switch automatically aligns the CITV with the Main Gun. When this switch is illuminated, you are in the GUN LINE OF SIGHT MODE.

Now, we will discuss the COMMANDER'S CONTROL HANDLE.

There are three controls located on the COMMANDER'S CONTROL HANDLE: the OPERATIONAL MODE switch, the PALM switch, and the LASER-FIRE AND TARGET-DESIGNATE BUTTON.

The OPERATIONAL MODE switch is located on top of the Commander's Control Handle. When pushed to the FORWARD position, it allows you to control the turret. The letter "T" will appear on the CITV screen. When pushed to the REAR position, it allows you to control the CITV. The letter "C" will appear on the CITV screen.

The PALM switch, when depressed, provides power to the Commander's Control Handle and the power for the CITV. When the OPERATIONAL MODE switch is in the CITV position and the PALM switch is depressed, the MANUAL SEARCH switch located on the bottom of the control panel will illuminate, and you are in the MANUAL SEARCH mode. The Manual Search mode provides you with the capability of using the Commander's Control Handle to manually control the CITV and search for targets using the CITV

strictly at your own command. It can also be used to interrupt Auto Scan for a closer look at a suspected target. The MANUAL SEARCH MODE can also be entered by pressing the MANUAL SEARCH switch on the bottom of the control panel.

The LASER-FIRE AND TARGET-DESIGNATE button is located on the left side of the Commander's Control Handle. When the OPERATIONAL MODE switch is in the "forward" position, the "laser range finder" is functional. Therefore, if you push the LASE button, it will operate as it does in the tank. However, when the OPERATIONAL MODE switch is in the CITV or "rear" position, the LASE button becomes a TARGET-DESIGNATE button. If you push this button while in the CITV mode you will slew the Main Gun and the Gunner's reticle to the exact spot where the CITV is aimed. You should only use this button to designate targets to the Gunner.

Now, we will discuss the ORIENTATION INDICATOR.

The ORIENTATION INDICATOR is located at the bottom center of the CITV screen. It is composed of three parts: the CITV, which is represented by a thin long line, the MAIN GUN, which is represented by a short thick line, and the HULL, which is represented by the two lines that run across the rectangular figure of the tank. The purpose of the ORIENTATION INDICATOR is to provide you with a visual reference regarding the relative positions of the CITV, HULL, and MAIN GUN with respect to each other. More details will be provided later.

Now, we will discuss the AUTO SCAN MODE.

When in the AUTO SCAN MODE, the CITV will automatically scan a sector that you set. First, make sure that the OPERATIONAL MODE switch on top of the COMMANDER'S CONTROL HANDLE is set to the rear or CITV position. Press the AUTO SCAN switch located at the bottom center of the control panel. The AUTO SCAN switch and the SECTOR SET switch will illuminate. Press the SECTOR SET switch. Grasp the commander's control handle and traverse left to your desired LEFT limit. Press the SECTOR SET switch again. That sets the left limit of your sector. Traverse right to your desired RIGHT limit. Press SECTOR SET again, and that sets the right limit of your sector. Scanning will begin from the right limit to the left limit. Press the RATE SET switch. It will illuminate, along with the INCREASE and DECREASE switches. Use the INCREASE and DECREASE switches to adjust the rate of scanning. Press the RATE SET switch again, and the rate you have selected will be maintained.

If you are in the AUTO SCAN MODE, and you wish to change to the MANUAL SEARCH MODE, press the Manual Search switch or grasp the commander's control handle. If you wish to return to Auto Scan, press the AUTO SCAN switch. After the left and right sector limits appear on the ORIENTATION INDICATOR, press the AUTO SCAN switch a second time. The CITV will then begin scanning from the left limit to the right limit of your sector.

There are some points about Auto Scan that you should note: First, when in Auto Scan, only the left and right limits of the sector will be visible on the ORIENTATION INDICATOR. You will not be able to see the CITV line-of-sight. To see the actual CITV LOS, you must go to the Manual Search Mode. Second, if you are in a moving-tank exercise, you will have to reset the sector limits every time the tank turns. Third, if you use Auto Scan, there will be times when you will be instructed to go to the Manual Search Mode. You should do so immediately and without hesitation by pressing the MANUAL SEARCH switch on the control panel. Fourth, you should note that you do not have to use the Auto Scan. You may use only the Manual Search if that is what you want to do.

Now, we will discuss what we want you to do.

You will be presented with scenes containing enemy targets. In some of the exercises, you will be in a defensive mode; in other words, the tank will be stationary. In other exercises, you will be in an offensive mode; in other words, the tank will be on the move. In some of the exercises, the targets will be short range, and in other exercises, the targets will be long range. However, all targets will be stationary. You will be informed of the particular situation at the beginning of each exercise.

You will use the CITV to scan a sector from the CENTER of the HULL to a point LEFT of the HULL. The Gunner will scan a sector from HULL CENTER to a point RIGHT of the HULL CENTER. The Gunner will not acquire any targets. However, if you detect any targets in your sector, you will begin engagement with a precision fire command, such as "Gunner, Sabot, Tank." You will then use the TARGET-DESIGNATE button on the Commander's Control Handle to slew the Gunner's reticle and MAIN GUN to the target area. You must make sure that the OPERATIONAL MODE switch is in the CITV position and that the PALM switch is depressed when you press the TARGET-DESIGNATE button. Once the Gunner has IDENTIFIED the target, RELEASE THE PALM SWITCH and hand off the target to the Gunner by saying "Fire and Adjust." You should then use the CITV to continue to search for additional targets in your sector. Upon completion of target engagements, designate the Gunner to the HULL CENTER so that he can begin scanning his assigned sector again.

You should be aware that the CITV can be rotated 360 degrees, but the field of view is only 270 degrees. When the CITV is rotated by the doghouse and the commander's cupula, the view is blocked and is simulated by a green background. Also, due to this particular test and this model of CITV there is no MAIN GUN obscuration.

In addition to acquiring targets, it is EQUALLY IMPORTANT that you maintain an awareness of the orientation of the HULL, the CITV, and the MAIN GUN. To do this, you must make use of the ORIENTATION INDICATOR. At some point during an exercise, the exercise will be halted, and you will be asked to indicate the

current positions of the HULL, CITV, and MAIN GUN using the POSITION INDICATOR RESPONSE FORMS we have prepared. Also, at some point during an exercise, the Gunner may scan to the RIGHT of his assigned sector. If you detect that the Gunner is scanning to the right of his assigned sector, you should immediately say "Gunner get back into sector." Also, if you receive any instructions during the exercises, such as "TC traverse to HULL CENTER" or "TC bring the GUN to HULL CENTER," you must do so immediately, and the ORIENTATION INDICATOR will help you. Finally, after you have completed all of the exercises, you will fill out an ORIENTATION INDICATOR QUESTIONNAIRE that asks you to evaluate the ORIENTATION INDICATOR.

You should be aware that the Gunner does not have an ORIENTATION INDICATOR. Therefore, the Gunner will be receiving instructions through his headphones as the exercises are running. Some of these instructions will be in code. You will hear this communication through your headphones, but you should not attempt to figure out the codes; it will only confuse you.

We will now discuss the ORIENTATION INDICATOR and what you must do in more detail. We will also give you some practice with the CITV.

The ORIENTATION INDICATOR is composed of three parts: the HULL, the CITV, and the MAIN GUN. All three parts can move. The Hull part moves only when the tank turns, and it moves in the direction of the turn. So, if the tank turns left, the Hull part moves left. Look at the 16 positions on the POSITION INDICATOR RESPONSE FORMS. These are the 16 positions the Hull part can be oriented. We have arbitrarily made the straight-up position NORTH. Tell me where the Hull is now pointed. The CITV and MAIN GUN parts can take on about twice as many positions as the HULL part. Therefore, there are essentially two CITV and MAIN GUN positions corresponding to each HULL position.

Make sure the OPERATIONAL MODE switch on the top of the commander's control handle is in the CITV or rear position.

If the CITV is either one CITV position to the left of Hull Center or one CITV position to the right of Hull Center, the CITV is considered to be oriented in the same direction as the HULL. Move the CITV one CITV position to the left of Hull Center and then one CITV position to the right of Hull Center. After each move, tell me where the CITV is oriented. The same holds true for the MAIN GUN.

If the CITV is either 2 or 3 CITV positions away from Hull Center, the CITV is one Hull Position away from Hull Center. Move the CITV 2 and then 3 CITV positions to the LEFT of Hull Center. After each move, tell me where the CITV is oriented. The same holds true for the MAIN GUN.

If the CITV is either 4 or 5 CITV positions away from Hull Center, the CITV is two Hull Positions away from Hull Center. Move the CITV 4 and then 5 CITV positions to the LEFT of Hull Center. After each move, tell me where the CITV is oriented. The same holds true for the MAIN GUN.

If the CITV is either 6 or 7 CITV positions away from Hull Center, the CITV is three Hull Positions away from Hull Center. Move the CITV 6 and then 7 CITV positions to the LEFT of Hull Center. After each move, tell me where the CITV is oriented. The same holds true for the MAIN GUN.

If the CITV is 8 CITV positions away from Hull Center, the CITV is four Hull Positions away from Hull Center. Move the CITV 8 CITV positions to the LEFT of Hull Center, and tell me where the CITV is oriented. The same holds true for the MAIN GUN.

Now, place the CITV at Hull Center. Move the CITV to the LEFT one CITV position at a time. After each move, tell me where the CITV is oriented. STOP when you have moved the CITV 8 CITV positions.

Now, place the CITV at Hull Center. Move the CITV to the RIGHT one CITV position at a time. After each move, tell me where the CITV is oriented. STOP when you have moved the CITV 8 CITV positions.

Place the CITV at Hull Center. Now, place the OPERATIONAL MODE switch on the commander's control handle in the Turret or forward position. Make sure the MAIN GUN is directly over Hull Center.

Now, move the MAIN GUN to the LEFT, one MAIN GUN position at a time. After each move, tell me where the MAIN GUN is oriented. STOP when you have moved the MAIN GUN 8 MAIN GUN positions.

Now, place the MAIN GUN directly over Hull Center. Move the MAIN GUN to the RIGHT, one MAIN GUN position at a time. After each move, tell me where the MAIN GUN is oriented. STOP when you have moved the MAIN GUN 8 MAIN GUN positions.

At certain points during the exercises, we will freeze the exercise. We will then ask you to use the POSITION INDICATOR RESPONSE FORMS to report the current positions of the HULL, the CITV, and the MAIN GUN, and the degree of confidence you have in each of your answers. Use the first page to report the position of the HULL, the second page to report the position of the CITV, and the third page to report the position of the MAIN GUN. Take a minute to look over the 3 pages.

DO YOU HAVE ANY QUESTIONS?

The ORIENTATION INDICATOR is composed of three parts: the HULL, the CITV, and the MAIN GUN. The CITV and MAIN GUN parts move, but the HULL part is stationary. In other words, the HULL part does not move. When the tank turns, in reality the HULL of the tank changes position. However, when the tank turns, the HULL part of the ORIENTATION INDICATOR will not move. What happens is that the CITV and MAIN GUN parts of the ORIENTATION INDICATOR rotate in the opposite direction that the tank turns. So, if the tank turns left, the Hull part of the ORIENTATION INDICATOR stays where it is; but the CITV and MAIN GUN parts shift to the RIGHT. Look at the 16 positions on the POSITION INDICATOR RESPONSE FORMS. These are the 16 positions the Hull can be oriented. We have arbitrarily made the straight-up position NORTH. Tell me where the Hull is now pointed. The CITV and MAIN GUN parts can take on about twice as many positions as the HULL part. Therefore, there are essentially two CITV and MAIN GUN positions corresponding to each HULL position.

Make sure the OPERATIONAL MODE switch on the top of the commander's control handle is in the CITV or rear position.

If the CITV is either one CITV position to the left of Hull Center or one CITV position to the right of Hull Center, the CITV is considered to be oriented in the same direction as the HULL. Move the CITV one CITV position to the left of Hull Center and then one CITV position to the right of Hull Center. After each move, tell me where the CITV is oriented. The same holds true for the MAIN GUN.

If the CITV is either 2 or 3 CITV positions away from Hull Center, the CITV is one Hull Position away from Hull Center. Move the CITV 2 and then 3 CITV positions to the LEFT of Hull Center. After each move, tell me where the CITV is oriented. The same holds true for the MAIN GUN.

If the CITV is either 4 or 5 CITV positions away from Hull Center, the CITV is two Hull Positions away from Hull Center. Move the CITV 4 and then 5 CITV positions to the LEFT of Hull Center. After each move, tell me where the CITV is oriented. The same holds true for the MAIN GUN.

If the CITV is either 6 or 7 CITV positions away from Hull Center, the CITV is three Hull Positions away from Hull Center. Move the CITV 6 and then 7 CITV positions to the LEFT of Hull Center. After each move, tell me where the CITV is oriented. The same holds true for the MAIN GUN.

If the CITV is 8 CITV positions away from Hull Center, the CITV is four Hull Positions away from Hull Center. Move the CITV 8 CITV positions to the LFFT of Hull Center, and tell me where the CITV is oriented. The same holds true for the MAIN GUN.

Now, place the CITV at Hull Center. Move the CITV to the LEFT one CITV position at a time. After each move, tell me where the CITV is oriented. STOP when you have moved the CITV 8 CITV positions.

Now, place the CITV at Hull Center. Move the CITV to the RIGHT one CITV position at a time. After each move, tell me where the CITV is oriented. STOP when you have moved the CITV 8 CITV positions.

Place the CITV at Hull Center. Now, place the OPERATIONAL MODE switch on the commander's control handle in the Turret or forward position. Make sure the MAIN GUN is directly over Hull Center.

Now, move the MAIN GUN to the LEFT, one MAIN GUN position at a time. After each move, tell me where the MAIN GUN is oriented. STOP when you have moved the MAIN GUN 8 MAIN GUN positions.

Now, place the MAIN GUN directly over Hull Center. Move the MAIN GUN to the RIGHT, one MAIN GUN position at a time. After each move, tell me where the MAIN GUN is oriented. STOP when you have moved the MAIN GUN 8 MAIN GUN positions.

At certain points during the exercises, we will freeze the exercise. We will then ask you to use the POSITION INDICATOR RESPONSE FORMS to report the current positions of the HULL, the CITV, and the MAIN GUN, and the degree of confidence you have in each of your answers. Use the first page to report the position of the HULL, the second page to report the position of the CITV, and the third page to report the position of the MAIN GUN. Take a minute to look over the 3 pages.

DO YOU HAVE ANY QUESTIONS?

The ORIENTATION INDICATOR is composed of three parts: the HULL, the CITV, and the MAIN GUN. The HULL and MAIN GUN parts move, but the CITV part is stationary. In other words, the CITV part does not move. As the tank turns, the HULL part of the orientation indicator moves in the direction of the turn. So, if the tank turns left, the HULL part moves left. If the CITV is rotated, the CITV part of the orientation indicator does not move. What happens is that the HULL and MAIN GUN parts of the orientation indicator move in the opposite direction of the CITV rotation.

Make sure the OPERATIONAL MODE switch on the commander's control handle is in the CITV or rear position. Now rotate the CITV LEFT. Notice what happens on the ORIENTATION INDICATOR: the CITV part remains stationary, but the HULL and MAIN GUN parts move to the RIGHT. This happens because in reality, as the CITV is rotated left, it gets farther away from the Hull and Main Gun. But the CITV part cannot move, so the HULL and MAIN GUN parts move in the opposite direction.

Look at the 16 positions on the POSITION INDICATOR RESPONSE FORMS. These are the 16 positions the HULL and CITV parts of the ORIENTATION INDICATOR can assume. We have arbitrarily chosen to make the straight-up position NORTH. Tell me where the Hull is now pointed. As the tank turns LEFT, the HULL part moves from NORTH to N/NW to NW and so on. As the tank turns RIGHT, the HULL part moves from NORTH to N/NE to NE and so on. As the CITV is rotated, the HULL part moves in the opposite direction because the CITV is stationary. So, if you move the CITV from NORTH to N/NW to NW and so on, what happens on the ORIENTATION INDICATOR is that the HULL part moves from NORTH to N/NE to NE and so on, even though the HULL didn't actually turn and therefore is actually still pointed NORTH.

Now, place the CITV at Hull Center. Rotate the CITV to the LEFT, one position at a time. After each move, tell me the directions the Hull and the CITV are pointed in reality.

Now, place the CITV at Hull Center. Rotate the CITV to the RIGHT, one position at a time. After each move, tell me the directions the Hull and the CITV are pointed in reality.

The MAIN GUN part of the ORIENTATION INDICATOR can assume about twice as many positions as the CITV and HULL parts. Thus, there are essentially 2 MAIN GUN positions for every CITV and HULL position.

Make sure the OPERATIONAL MODE switch on the commander's control handle is in the Turret or forward position.

If the MAIN GUN is either one MAIN GUN position to the left of Hull Center or one MAIN GUN position to the right of Hull Center, the MAIN GUN is considered to be oriented in the same direction

as the Hull. Move the MAIN GUN one MAIN GUN position to the LEFT and then one MAIN GUN position to the RIGHT of Hull Center. After each move, tell me where the MAIN GUN is oriented.

If the MAIN GUN is either 2 or 3 MAIN GUN positions away from Hull Center, the MAIN GUN is one HULL position away from Hull Center. Move the MAIN GUN 2 and then 3 MAIN GUN positions to the LEFT of Hull Center. After each move, tell me where the MAIN GUN is oriented.

If the MAIN GUN is either 4 or 5 MAIN GUN positions away from Hull Center, the MAIN GUN is two HULL position away from Hull Center. Move the MAIN GUN 4 and then 5 MAIN GUN positions to the LEFT of Hull Center. After each move, tell me where the MAIN GUN is oriented.

If the MAIN GUN is either 6 or 7 MAIN GUN positions away from Hull Center, the MAIN GUN is three HULL position away from Hull Center. Move the MAIN GUN 6 and then 7 MAIN GUN positions to the LEFT of Hull Center. After each move, tell me where the MAIN GUN is oriented.

If the MAIN GUN is 8 MAIN GUN positions away from Hull Center, the MAIN GUN is four HULL position away from Hull Center. Move the MAIN GUN 8 MAIN GUN positions to the LEFT of Hull Center, and tell me where the MAIN GUN is oriented.

Now, place the MAIN GUN at Hull Center. Move the MAIN GUN to the RIGHT, one MAIN GUN position at a time. After each move, tell me where the MAIN GUN is oriented. STOP when you have moved the MAIN GUN 8 MAIN GUN positions.

At certain points during the exercises, we will freeze the exercise. We will then ask you to use the POSITION INDICATOR RESPONSE FORMS to report the current positions of the HULL, the CITV, and the MAIN GUN, and the degree of confidence you have in each of your answers. Use the first page to report the position of the HULL, the second page to report the position of the CITV, and the third page to report the position of the MAIN GUN. Take a minute to look over the 3 pages.

DO YOU HAVE ANY QUESTIONS?

The ORIENTATION INDICATOR is composed of three parts: the HULL, the CITV, and the MAIN GUN. The HULL and CITV parts move, but the MAIN GUN part is stationary. In other words, the MAIN GUN part does not move. As the tank turns, the HULL part of the orientation indicator moves in the direction of the turn. So, if the tank turns left, the HULL part moves left. If the MAIN GUN is rotated, the MAIN GUN part of the orientation indicator does not move. What happens is that the HULL and CITV parts of the orientation indicator move in the opposite direction of the MAIN GUN rotation.

Make sure the OPERATIONAL MODE switch on the commander's control handle is in the Turret or forward position. Now rotate the MAIN GUN RIGHT. Notice what happens on the ORIENTATION INDICATOR: the MAIN GUN part remains stationary, but the HULL and CITV parts move to the LEFT. This happens because in reality, as the MAIN GUN is rotated right, it gets farther away from the HULL and CITV. But the MAIN GUN part cannot move, so the HULL and CITV parts move in the opposite direction.

Look at the 16 positions on the POSITION INDICATOR RESPONSE FORMS. These are the 16 positions the HULL and MAIN GUN parts of the ORIENTATION INDICATOR can assume. We have arbitrarily chosen to make the straight-up position NORTH. Tell me where the HULL is now pointed. As the tank turns LEFT, the HULL part moves from NORTH to N/NW to NW and so on. As the tank turns RIGHT, the HULL part moves from NORTH to N/NE to NE and so on. As the MAIN GUN is rotated, the HULL part moves in the opposite direction because the MAIN GUN is stationary. So, if you move the MAIN GUN from NORTH to N/NE to NE and so on, what happens on the ORIENTATION INDICATOR is that the HULL part moves from NORTH to N/NW to NW and so on, even though the HULL didn't actually turn and therefore is actually still pointed NORTH.

Now, place the MAIN GUN at Hull Center. Rotate the MAIN GUN to the RIGHT, one position at a time. After each move, tell me the directions the HULL and the MAIN GUN are pointed in reality.

Now, place the MAIN GUN at Hull Center. Rotate the MAIN GUN to the LEFT, one position at a time. After each move, tell me the directions the HULL and the MAIN GUN are pointed in reality.

The CITV part of the ORIENTATION INDICATOR can assume about twice as many positions as the HULL and MAIN GUN parts. Thus, there are essentially 2 CITV positions for every MAIN GUN and HULL position.

Make sure the OPERATIONAL MODE switch on the commander's control handle is in the CITV or rear position.

If the CITV is either one CITV position to the left of Hull Center or one CITV position to the right of Hull Center, the CITV

is considered to be oriented in the same direction as the Hull. Move the CITV one CITV position to the LEFT and then one CITV position to the RIGHT of Hull Center. After each move, tell me where the CITV is oriented.

If the CITV is either 2 or 3 CITV positions away from Hull Center, the CITV is one HULL position away from Hull Center. Move the CITV 2 and then 3 CITV positions to the LEFT of Hull Center. After each move, tell me where the CITV is oriented.

If the CITV is either 4 or 5 CITV positions away from Hull Center, the CITV is two HULL position away from Hull Center. Move the CITV 4 and then 5 CITV positions to the LEFT of Hull Center. After each move, tell me where the CITV is oriented.

If the CITV is either 6 or 7 CITV positions away from Hull Center, the CITV is three HULL position away from Hull Center. Move the CITV 6 and then 7 CITV positions to the LEFT of Hull Center. After each move, tell me where the CITV is oriented.

If the CITV is 8 CITV positions away from Hull Center, the CITV is four HULL position away from Hull Center. Move the CITV 8 CITV positions to the LEFT of Hull Center, and tell me where the CITV is oriented.

Now, place the CITV at Hull Center. Move the CITV to the RIGHT, one CITV position at a time. After each move, tell me where the CITV is oriented. STOP when you have moved the CITV 8 CITV positions.

At certain points during the exercises, we will freeze the exercise. We will then ask you to use the POSITION INDICATOR RESPONSE FORMS to report the current positions of the HULL, the CITV, and the MAIN GUN, and the degree of confidence you have in each of your answers. Use the first page to report the position of the HULL, the second page to report the position of the CITV, and the third page to report the position of the MAIN GUN. Take a minute to look over the 3 pages.

DO YOU HAVE ANY QUESTIONS?

APPENDIX C

Orientation Indicator Questionnaire

RP#: _____ Group: ALLMOV Date: _____ Time: _____

1. When using the CITV, how important do you feel it is to know the locations of the CITV, Hull, and Main Gun? Place a 1 in the blank of what you feel is most important to know, a 2 in the blank of the second most important, and a 3 in the blank of the third most important. If you feel that any two or all three are equally important to know, ask Dr. Fisicaro for more information.

_____ CITV
_____ Hull
_____ Main Gun
6 Total (points must add up to 6)

2. Complete the following statements by CIRCLING the appropriate number.

   a. I think that it is _____ to use this orientation indicator to keep track of the CITV location.

      6: Extremely Difficult
      5: Very Difficult
      4: Difficult
      3: Easy
      2: Very Easy
      1: Extremely Easy

   b. I think that it is _____ to use this orientation indicator to keep track of the Hull location.

      6: Extremely Difficult
      5: Very Difficult
      4: Difficult
      3: Easy
      2: Very Easy
      1: Extremely Easy

   c. I think that it is _____ to use this orientation indicator to keep track of the Main Gun location.

      6: Extremely Difficult
      5: Very Difficult
      4: Difficult
      3: Easy
      2: Very Easy
      1: Extremely Easy

3. Do you think that additional practice using the orientation indicator would help you become more effective in using the orientation indicator?
Place an "X" in the appropriate blank.

_____ Yes
_____ No

4. In the orientation indicator you used, all three parts were moving; in other words, none of the three parts were stationary. If you had your choice, which <u>one</u> of the following would you select regarding moving vs. stationary parts of the orientation indicator?
Place an "X" in the appropriate blank.

_____ Leave it as it is: All three parts should be moving.
_____ Change it: The Hull should be stationary, and the CITV and Main Gun should be moving.
_____ Change it: The Main Gun should be stationary, and the CITV and Hull should be moving.
_____ Change it: The CITV should be stationary, and the Hull and Main Gun should be moving.

5. Describe any problems you had in using the orientation indicator. Be as specific as possible.

6. Describe any changes you would make in the orientation indicator, including anything you would add to it or anything you would remove from it. Be as specific as possible.

APPENDIX D

Position Indicator Response Forms

Position Indicator Response Form

Exercise 932110

RP#: _____ Group: ALLMOV G: _____ Date: _____ Time: _____

Question #1A: Indicate the direction the HULL of your tank is now pointed by circling the appropriate compass direction.

NORTH

N/NW N/NE

NW NE

W/NW E/NE

WEST EAST

W/SW E/SE

SW SE

S/SW S/SE

SOUTH

Question #1B: Indicate the degree of confidence you have in your answer by circling the appropriate number below.

5: Totally confident
4: Very confident
3: Moderately confident
2: Not very confident
1: Not at all confident

Position Indicator Response Form

Exercise 932110

RP#: _____ Group: ALLMOV G: _____ Date: _____ Time: _____

Question #2A: Indicate the direction the CITV is now pointed by circling the appropriate compass direction.

NORTH

N/NW N/NE

NW NE

W/NW E/NE

WEST EAST

W/SW E/SE

SW SE

S/SW S/SE

SOUTH

Question #2B: Indicate the degree of confidence you have in your answer by circling the appropriate number below.

5: Totally confident
4: Very confident
3: Moderately confident
2: Not very confident
1: Not at all confident

Position Indicator Response Form

Exercise 932110

RP#: _____ Group: ALLMOV G: _____ Date: _____ Time: _____

Question #3A: Indicate the direction the MAIN GUN is now pointed by circling the appropriate compass direction.

NORTH

N/NW N/NE

NW NE

W/NW E/NE

WEST EAST

W/SW E/SE

SW SE

S/SW S/SE

SOUTH

Question #3B: Indicate the degree of confidence you have in your answer by circling the appropriate number below.

5: Totally confident
4: Very confident
3: Moderately confident
2: Not very confident
1: Not at all confident

APPENDIX E

Results of Analyses of Biographical Questionnaire Items

Table E-1

Means (M) and Standard Deviations (SD) for Select Biographical Questionnaire Items as a Function of Icon Group.

Item Number: Measure	Icon Group: All Moving (N = 11)	Hull Stat (N = 11)	CITV Stat (N = 11)	Gun Stat (N = 11)
5. GT Score				
M	108.18	108.18	107.36	107.00
SD	7.59	12.26	14.18	13.33
6. Service (Months)				
M	108.18	120.00	122.55	140.18
SD	42.50	24.62	43.79	58.06
7. Armor MOS (Months)				
M	106.36	98.46	107.64	122.64
SD	43.99	19.85	45.78	49.56
14. Time (Months) as: TC				
M	43.00	42.18	50.91	68.18
SD	54.08	18.82	48.76	45.36
M60 TC				
M	21.09	13.18	26.73	46.55
SD	28.51	17.52	34.69	45.40
M1 TC				
M	15.73	23.46	15.46	18.00
SD	25.27	18.84	20.22	18.87
M1A1 TC				
M	4.64	5.91	1.09	1.82
SD	7.98	8.81	3.62	6.03
15. Number of COFT Firing Sessions				
M	61.00	56.27	70.55	41.09
SD	72.13	43.82	91.98	62.03
16. Hours Spent Firing COFT				
M	125.82	120.00	179.27	78.55
SD	147.82	78.07	246.62	87.20

Note. Stat refers to stationary part of the icon.

Table E-2

Between-Subjects Analysis-of-Variance Results for Biographical Information as a Function of Icon.

Source	df	SS	MS	F
Dependent Variable: General Technical Score				
Icon	3	11.73	3.91	<1.00
Error	40	5865.82	146.65	
Dependent Variable: Months in Service				
Icon	3	5760.73	1920.24	<1.00
Error	40	77010.00	1925.25	
Dependent Variable: Months in Armor MOS				
Icon	3	33[illegible]5	1121.12	<1.00
Error	40	68812[illegible]5	1720.31	
Dependent Variable: Months as a Tank Commander				
Icon	3	4806.61	1602.20	<1.00
Error	40	77140.18	1928.50	
Dependent Variable: Months as M60 Tank Commander				
Icon	3	6686.98	2228.99	2.03
Error	40	43843.45	1096.09	
Dependent Variable: Months as M1 Tank Commander				
Icon	3	454.25	151.42	<1.00
Error	40	17585.64	439.64	
Dependent Variable: Months as M1A1 Tank Commander				
Icon	3	172.18	57.39	1.20
Error	40	1908.00	47.70	
Dependent Variable: Number of COFT Firing Sessions				
Icon	3	4981.91	1660.64	<1.00
Error	40	194309.82	4857.75	
Dependent Variable: Hours Spent Firing COFT				
Icon	3	56385.09	18795.03	<1.00
Error	40	963728.55	24093.21	

Note. None of the F ratios are significant at the .05 level.

APPENDIX F

Results of Analyses of Position Deviation Measures, Confidence Ratings, and Position Differential Measures

Table F-1

Analysis-of-Variance Results for Errors in Judging Hull Orientation as a Function of Icon, Tank Mode, and Target Range.

Source	df	SS	MS	F
Icon	3	5.02	1.67	4.92**
AH-CG	1	2.05	2.05	6.04**
A-H	1	2.56	2.56	7.53**
C-G	1	.41	.41	1.20
Error (S/Icon)	40	13.59	.34	
Tank Mode	1	17.19	17.19	55.81**
Icon X Tank Mode	3	4.24	1.41	4.59**
AH-CG X Tank Mode	1	.96	.96	3.12*
A-H X Tank Mode	1	2.56	2.56	8.30**
Error (S/Icon X Tank Mode)	40	12.32	.31	
Target Range	1	.01	.01	<1.00
Icon X Target Range	3	.34	.11	<1.00
Error (S/Icon X Target Range)	40	10.41	.26	
Tank Mode X Target Range	1	.05	.05	<1.00
Icon X Tank Mode X Target Range	3	.65	.22	<1.00
Error (S/Icon X Tank Mode X Target Range)	40	10.05	.25	
Total	175	73.87		

Note. AH-CG indicates a comparison of the All Moving and Hull Stationary Icon Groups with the CITV Stationary and Main Gun Stationary Icon Groups; A-H indicates a comparison of the All Moving Icon Group with the Hull Stationary Icon Group; C-G indicates a comparison between the CITV Stationary Icon Group and the Main Gun Stationary Icon Group.

* $p < .10$; ** $p < .05$.

Table F-2

Analysis-of-Variance Results for Errors in Judging CITV Orientation as a Function of Icon, Tank Mode, and Target Range.

Source	df	SS	MS	F
Icon	3	6.84	2.28	4.46**
AH-CG	1	3.55	3.55	6.94**
A-H	1	.73	.73	1.42
C-G	1	2.56	2.56	5.00**
Error (S/Icon)	40	20.45	.51	
Tank Mode	1	15.96	15.96	44.17**
Icon X Tank Mode	3	2.84	.95	2.62*
A-H X Tank Mode	1	2.23	2.23	6.16**
Error (S/Icon X Tank Mode)	40	14.45	.36	
Target Range	1	.05	.05	<1.00
Icon X Target Range	3	2.11	.70	2.53*
A-H X Target Range	1	1.14	1.14	4.10**
C-G X Target Range	1	.92	.92	3.32*
Error (S/Icon X Target Range)	40	11.09	.28	
Tank Mode X Target Range	1	.28	.28	<1.00
Icon X Tank Mode X Target Range	3	2.43	.81	2.22
Error (S/Icon X Tank Mode X Target Range)	40	14.55	.36	
Total	175	91.05		

Note. AH-CG indicates a comparison of the All Moving and Hull Stationary Icon Groups with the CITV Stationary and Main Gun Stationary Icon Groups; A-H indicates a comparison of the All Moving Icon Group with the Hull Stationary Icon Group; C-G indicates a comparison between the CITV Stationary Icon Group and the Main Gun Stationary Icon Group.

* $p < .10$; ** $p < .05$.

Table F-3

Analysis-of-Variance Results for Errors in Judging Main Gun Orientation as a Function of Icon, Tank Mode, and Target Range.

Source	df	SS	MS	F
Icon	3	3.29	1.10	1.95
AH-CG	1	.14	.14	<1.00
A-H	1	2.23	2.23	3.97*
C-G	1	.92	.92	1.64
Error (S/Icon)	40	22.45	.56	
Tank Mode	1	8.64	8.64	17.85**
Icon X Tank Mode	3	6.24	2.08	4.30**
A-H X Tank Mode	1	3.68	3.68	7.61**
C-G X Tank Mode	1	2.56	2.56	5.28**
Error (S/Icon X Tank Mode)	40	19.36	.48	
Target Range	1	.05	.05	<1.00
Icon X Target Range	3	4.93	1.64	4.95**
A-H X Target Range	1	3.68	3.68	11.10**
Error (S/Icon X Target Range)	40	13.27	.33	
Tank Mode X Target Range	1	.14	.14	<1.00
Icon X Tank Mode X Target Range	3	.74	.25	<1.00
Error (S/Icon X Tank Mode X Target Range)	40	16.36	.41	
Total	175	95.47		

Note. AH-CG indicates a comparison of the All Moving and Hull Stationary Icon Groups with the CITV Stationary and Main Gun Stationary Icon Groups; A-H indicates a comparison of the All Moving Icon Group with the Hull Stationary Icon Group; C-G indicates a comparison between the CITV Stationary Icon Group and the Main Gun Stationary Icon Group.

* $p < .10$; ** $p < .05$.

Table F-4

Analysis-of-Variance Results for Confidence Ratings in Judging Hull Orientation as a Function of Icon, Tank Mode, and Target Range.

Source	df	SS	MS	F
Icon	3	9.34	3.11	3.17**
AH-CG	1	7.78	7.78	7.93**
A-H	1	1.38	1.38	1.40
C-G	1	.18	.18	<1.00
Error (S/Icon)	40	39.23	.98	
Tank Mode	1	43.01	43.01	68.19**
Icon X Tank Mode	3	9.52	3.17	5.03**
AH-CG X Tank Mode	1	2.51	2.51	3.97*
A-H X Tank Mode	1	4.10	4.10	6.50**
C-G X Tank Mode	1	2.91	2.91	4.61**
Error (S/Icon X Tank Mode)	40	25.23	.63	
Target Range	1	.14	.14	<1.00
Icon X Target Range	3	1.20	.40	1.70
Error (S/Icon X Target Range)	40	9.41	.24	
Tank Mode X Target Range	1	.28	.28	1.08
Icon X Tank Mode X Target Range	3	1.15	.38	1.49
Error (S/Icon X Tank Mode X Target Range)	40	10.32	.26	
Total	175	148.83		

Note. AH-CG indicates a comparison of the All Moving and Hull Stationary Icon Groups with the CITV Stationary and Main Gun Stationary Icon Groups; A-H indicates a comparison of the All Moving Icon Group with the Hull Stationary Icon Group; C-G indicates a comparison between the CITV Stationary Icon Group and the Main Gun Stationary Icon Group.

* $p < .10$; ** $p < .05$.

Table F-5

Analysis-of-Variance Results for Confidence Ratings in Judging CITV Orientation as a Function of Icon, Tank Mode, and Target Range.

Source	df	SS	MS	F
Icon	3	10.95	3.65	2.94**
AH-CG	1	8.20	8.20	6.61**
A-H	1	1.38	1.38	1.11
C-G	1	1.38	1.38	1.11
Error (S/Icon)	40	49.68	1.24	
Tank Mode	1	16.57	16.57	31.22**
Icon X Tank Mode	3	3.20	1.07	2.01
A-H X Tank	1	1.92	1.92	3.62*
Error (S/Icon X Tank Mode)	40	21.23	.53	
Target Range	1	.02	.02	<1.00
Icon X Target Range	3	.11	.11	<1.00
Error (S/Icon X Target Range)	40	12.86	.32	
Tank Mode X Target Range	1	1.45	1.45	6.63**
Icon X Tank Mode X Target Range	3	.77	.26	1.17
Error (S/Icon X Tank Mode X Target Range)	40	8.77	.22	
Total	175	125.61		

Note. AH-CG indicates a comparison of the All Moving and Hull Stationary Icon Groups with the CITV Stationary and Main Gun Stationary Icon Groups; A-H indicates a comparison of the All Moving Icon Group with the Hull Stationary Icon Group; C-G indicates a comparison between the CITV Stationary Icon Group and the Main Gun Stationary Icon Group.

* $p < .10$; ** $p < .05$.

Table F-6

Analysis-of-Variance Results for Confidence Ratings in Judging Main Gun Orientation as a Function of Icon, Tank Mode, and Target Range.

Source	df	SS	MS	F
Icon	3	5.93	1.98	1.18
AH-CG	1	5.46	5.46	3.27*
A-H	1	.28	.28	<1.00
C-G	1	.18	.18	<1.00
Error (S/Icon)	40	66.86	1.67	
Tank Mode	1	13.64	13.64	27.73**
Icon X Tank Mode	3	5.93	1.98	4.01**
A-H X Tank Mode	1	4.10	4.10	8.34**
Error (S/Icon X Tank Mode)	40	19.68	.49	
Target Range	1	.01	.01	<1.00
Icon X Target Range	3	.47	.16	<1.00
Error (S/Icon X Target Range)	40	15.77	.39	
Tank Mode X Target Range	1	.28	.28	1.15
Icon X Tank Mode X Target Range	3	.29	.10	<1.00
Error (S/Icon X Tank Mode X Target Range)	40	9.68	.24	
Total	175	138.54		

Note. AH-CG indicates a comparison of the All Moving and Hull Stationary Icon Groups with the CITV Stationary and Main Gun Stationary Icon Groups; A-H indicates a comparison of the All Moving Icon Group with the Hull Stationary Icon Group; C-G indicates a comparison between the CITV Stationary Icon Group and the Main Gun Stationary Icon Group.

* $p < .10$; ** $p < .05$.

Table F-7

Analysis-of-Variance Results for Hull-CITV Position Differential Errors as a Function of Icon, Tank Mode, and Target Range.

Source	df	SS	MS	F
Icon	3	7.93	2.64	4.54**
AH-CG	1	.82	.82	1.40
A-H	1	.01	.01	<1.00
C-G	1	7.10	7.10	12.18**
Error (S/Icon)	40	23.32	.58	
Tank Mode	1	2.27	2.27	4.71**
Icon X Tank Mode	3	1.41	.47	<1.00
Error (S/Icon X Tank Mode)	40	19.32	.48	
Target Range	1	.00	.00	<1.00
Icon X Target Range	3	.32	.11	<1.00
Error (S/Icon X Target Range)	40	7.68	.19	
Tank Mode X Target Range	1	.02	.02	<1.00
Icon X Tank Mode X Target Range	3	.75	.25	<1.00
Error (S/Icon X Tank Mode X Target Range)	40	12.23	.31	
Total	175	75.25		

Note. AH-CG indicates a comparison of the All Moving and Hull Stationary Icon Groups with the CITV Stationary and Main Gun Stationary Icon Groups; A-H indicates a comparison of the All Moving Icon Group with the Hull Stationary Icon Group; C-G indicates a comparison between the CITV Stationary Icon Group and the Main Gun Stationary Icon Group.

** $p < .05$.

Table F-8

Analysis-of-Variance Results for Hull-Gun Position Differential Errors as a Function of Icon, Tank Mode, and Target Range.

Source	df	SS	MS	F
Icon	3	1.02	.34	<1.00
AH-CG	1	.09	.09	<1.00
A-H	1	.92	.92	1.80
C-G	1	.01	.01	<1.00
Error (S/Icon)	40	20.45	.51	
Tank Mode	1	1.84	1.84	5.36**
Icon X Tank Mode	3	1.93	1.93	1.88
A-H X Tank Mode	1	1.92	1.92	5.60**
Error (S/Icon X Tank Mode)	40	13.73	.34	
Target Range	1	.00	.00	<1.00
Icon X Target Range	3	4.14	1.38	4.46**
A-H X Target Range	1	3.28	3.28	10.63**
Error (S/Icon X Target Range)	40	12.36	.31	
Tank Mode X Target Range	1	.09	.09	<1.00
Icon X Tank Mode X Target Range	3	.59	.20	<1.00
Error (S/Icon X Tank Mode X Target Range)	40	11.82	.30	
Total	175	67.97		

Note. AH-CG indicates a comparison of the All Moving and Hull Stationary Icon Groups with the CITV Stationary and Main Gun Stationary Icon Groups; A-H indicates a comparison of the All Moving Icon Group with the Hull Stationary Icon Group; C-G indicates a comparison between the CITV Stationary Icon Group and the Main Gun Stationary Icon Group.

** $p < .05$.

Table F-9

Analysis-of-Variance Results for CITV-Gun Position Differential Errors as a Function of Icon, Tank Mode, and Target Range.

Source	df	SS	MS	F
Icon	3	2.02	.67	<1.00
AH-CG	1	.57	.57	<1.00
A-H	1	.73	.73	<1.00
C-G	1	.73	.73	<1.00
Error (S/Icon)	40	34.14	.85	
Tank Mode	1	.36	.36	<1.00
Icon X Tank Mode	3	3.23	1.08	2.22
A-H X Tank Mode	1	2.23	2.23	4.59**
Error (S/Icon X Tank Mode)	40	19.41	.49	
Target Range	1	.02	.02	<1.00
Icon X Target Range	3	2.48	.83	2.28*
A-H X Target Range	1	2.23	2.23	6.14**
Error (S/Icon X Target Range)	40	14.50	.36	
Tank Mode X Target Range	1	.09	.09	<1.00
Icon X Tank Mode X Target Range	3	1.23	.41	<1.00
Error (S/Icon X Tank Mode X Target Range)	40	16.68	.42	
Total	175	94.16		

Note. AH-CG indicates a comparison of the All Moving and Hull Stationary Icon Groups with the CITV Stationary and Main Gun Stationary Icon Groups; A-H indicates a comparison of the All Moving Icon Group with the Hull Stationary Icon Group; C-G indicates a comparison between the CITV Stationary Icon Group and the Main Gun Stationary Icon Group.

* $p < .10$; ** $p < .05$.